Management Guidelines For Implementation

Biodiversity Management Of Wetlands

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Foreword

The significance of Iran's wetlands for global biodiversity is unparalleled in the Middle East, and as the birthplace of the Ramsar Convention, Iran has long-signalled its commitment to wetland conservation. However, the rapid pace of development in the country has put enormous pressure on land and water resources in recent decades, such that the system of protected areas is struggling to maintain the condition of several of these internationally important wetlands and the biodiversity they support.

The Government of the Islamic Republic of Iran and UNDP have joined forces with the support of the Global Environment Facility to address the issue of sustainable wetland management through the Conservation of Iranian Wetlands Project. This 7-year initiative – which began on 26 January 2005 – provides a unique opportunity to build national and local capacity for improved management of wetlands and their globally significant biodiversity, and to raise the awareness of all stakeholders of their respective responsibilities.

As the International Wetlands Biodiversity Expert (WBE) I have provided brief and intermittent inputs to the project since February 2007, together with the national WBE Ms Lisa Pourlak. The present is the background document for a training programme provided to DoE offices in Uromiyeh, Shiraz, Ahwaz and Tehran in May 2011, which was subsequently published as a guideline.

This part of the Project Toolkit on Biodiversity Management was presented as a 1-day training workshop on "Managing and Restoring Wetland Biodiversity", held three times during 21-31 May 2011, for members of the three Biodiversity Working Groups as well as other members from the community, academia, NGOs, government agencies at Uromiyeh, Ahwaz and Kazeroun.

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Introduction

Why is biodiversity important?

Biological diversity, or biodiversity1, is a relatively recent concept that emerged as part of environmental awareness that arose in the second half of the 20th century. We have come to value biological diversity for its uses (e.g. biological products and functions, often with economic value2), but also for cultural and intrinsic values. We have also come to realise that ecosystems with greater biodiversity are often more resilient (for example against disturbances or change), and if we impoverish ecosystems they are more susceptible to degradation and collapse. Also, the concept of "man as the steward of nature", who is responsible for maintaining it in all its manifestations, including biodiversity, is a view that has taken hold over the past decades. Humans can degrade and destroy, but also manage, nurture and maintain the environment.

Wetlands occupy a special place in overall biodiversity, as they are particularly rich, be it in number of species, absolute numbers and in productivity. Wetlands are often spectacles to behold, with large congregations of wildlife, but they are also sensitive and fragile. They are vulnerable to pollution, drought, over utilisation by man, and many wetlands world-wide have lost their diversity due to abuse, of have even disappeared altogether. Table 1 summarises the main threats to wetlands. For example, a third of all mangroves world-wide disappeared between 1980-2000 (Rocchio, 2010), and in Indonesia, 96% of all peat swamp forests formerly on Borneo and Sumatra islands (i.e. 13 million ha) were degraded (logged, drained) by 2007 and are still under threat (Mittienen & Liew, 2010). In the USA, the lower 48 states had lost more than half of all their wetlands by 1980, with seven states having lost more than 80% (Mitsch & Gosselink, 1983). In Europe, the situation is similar, with more than 50% of all wetlands having disappeared over the past century (Silva *et al.*, 2007). However, when managed wisely, wetlands can remain productive and be of use to man, while at the same time maintaining their importance for biological diversity.

1- There are various definitions for biodiversity, some of the more commonly used are: i) IUCN: Biological diversity is the variety of life forms...at all levels of biological systems (i.e., molecular, organismic, population, species and ecosystem); ii) The 1992 United Nations Earth Summit defined "biological diversity" as "the variability among living organisms from all sources, including, 'inter alia', terrestrial, marine, and other aquatic ecosystems, and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems" (this is used by the Convention on Biological Diversity or CBD); and iii) Wikipedia: Biodiversity is the degree of variation of life forms within a given ecosystem, biome, or an entire planet.

2- Economic value of wetlands can be very significant; 2 examples: i) In the Maldives, biodiversity supports 71% of national employment, 98% of exports and 89% of GDP through tourism and fisheries. ii) Few countries in the world are so dependent on inland fisheries as is Cambodia where fish provides people with 80 % of their animal protein, and fish also contribute 16 % to the country's GDP.

Table 1 Major Causes of Wetland Loss and Degradation

Major threats	Direct causes of wetland degradation & loss	
Human Actions	Drainage Dredging & stream channelization Deposition of fill material Diking and damming Tilling for crop production Levees Logging Climate change (including sea level rise, changes in rainfall & temperature, acidification of the sea)	Mining Construction Runoff Air and water pollutants Changing nutrient levels Releasing toxic chemicals Introducing non-native species Grazing by domestic animals Water diversion for other uses
Natural Threats	Erosion Subsidence Sea level rise	Droughts Hurricanes and other storms Climate change

Adapted (and added to) from Mitsch & Gosselink (1983)

Importance of wetlands in Iran and the region

In a global context, Iran is a dry country, dominated by arid and semi-arid regions, and over 60% of its land is classified as such. For outsiders, it is therefore surprising that Iran possesses a large number and wide variety of wetlands. To date, more than 1,000 have been identified, ranging from the inlets and marshes of the Caspian lowlands to the natural inland delta of Sistan in eastern Iran; from the vast salt lakes of the central plateau to the Mesopotamian deltas at the head of the Persian Gulf; and from the lakes of the Turkman steppes to the tidal mangroves and mudflats of the Persian Gulf coast. As the country is generally (semi-) arid, these wetlands are veritable oases that maintain local (micro-) climate and diversity, both in total species and in absolute numbers. Some of the key wetland complexes are listed in the Project Brief for CIWP (see Summary Table 2).

Table 2 Biodiversity importance ranking of internationally significant wet-laxnds in Iran, grouped by major wetlands system

Name of site	Reasons for inclusion	Score	# of globally threatened species	Score	# of 1% species	Score	Total
System 1: Central Fars							
Dasht-e Arjan and Lake Parishan	6	12	5	20	19	19	51
Lake Bakhtegan, Lake Tashk and Kamjan Marshes	5	10	3	12	19	19	41
Lake Maharlu	3	6	5	20	6	6	32
System 2: Khuzestan							
Karun River Marshes	3	6	5	20	6	6	32
Dez River Marshes and Plains	4	8	5	20	3	3	31
Horeh Bamdej (Sadi Shavour Marshes)	5	10	3	12	9	9	31
System 3: Persian Gulf and Gulf of Oman							

Name of site	Reasons for inclusion	Score	# of globally threatened species	Score	# of 1% species	Score	Total
Shadegan Marshes and Tidal Mudflats of Khor-al Amaya and Khor Musa	7	14	4	16	15	15	45
Delta of Helleh River	5	10	4	16	9	9	35
Khouran Straits	6	12	2	8	8	8	28
System 4: Sistan Basin							
South end of Hamoun-i Puzak	6	12	5	20	11	11	43
Hamoun-i Sabari and Hamoun-i Hirmand	6	12	4	16	13	13	41
System 5: South Caspian							
Miankaleh Peninsula and Gorgan Bay	7	14	4	16	34	34	64
Anzali Mordab Complex	7	14	3	12	18	18	44
Gomishan Marshes and Turkoman Steppes	4	8	2	8	16	16	32

Name of site	Reasons for inclusion	Score	# of globally threatened species	Score	# of 1% species	Score	Total
System 6: Uromiyeh Basin							
Shur Gol, Yadegarlu and Dorgeh Sangi Lakes	4	8	5	20	8	8	36
Lake Uromiyeh	6	12	2	8	15	15	35
Lake Kobi	4	8	3	12	8	8	28

Source: UNDP-GEF Conservation of Iranian Wetlands Brief, June 2003.

Importance of Iranian wetlands for biodiversity

Wetlands can be important to biodiversity in various ways, all of which add to the relative importance of a particular wetland site. Some commonly used indicators of importance to biodiversity are:

- ☑ Presence of rare, endangered, endemic species,
- ☑ Presence of rare or endangered habitats,
- ☑ Presence of large numbers of species,
- ☑ Importance of wetlands in the lifecycle of rare, endangered or endemic species.

Wetlands that are found to be of international importance and that meet the criteria of the Ramsar Convention (see www.ramsar.org) may be designated as Ramsar sites. Iran's wetlands are of tremendous national, regional and global significance, and according to a definitive study on wetlands of the Middle East (Scott, 1995), Iran supports 63 wetlands that meet one or more Ramsar criteria for international importance. This figure represents nearly 40% of the 160 wetlands of international importance identified within 13 countries surveyed throughout the Middle East. Recent studies by Iran's Department of Environment (DoE) have resulted in an increase in the estimated number of wetlands of international significance to 76. Many of these potential Ramsar sites correspond with the more than 105 Important Bird Area (IBAs) identified to date (www.birdlife.org; Evans, 1994).

However, Iran's wetlands are not only important for birds, but also for a host of fish, amphibians, plants, reptiles and mammal species. Iran's wetlands are very important for six species of birds listed as globally threatened in IUCN's List of Threatened Animals, i.e. Pygmy Cormorant (*Phalacrocorax pygmaeus), Dalmatian Pelican (Pelecanus crispus), Lesser White-fronted Goose (Anser erythropus), Marbled Teal (Marmaronetta angustirostris), White-headed Duck (Oxyura leucocephala), and White-tailed Eagle (Haliaeetus albicilla). Five more threatened species, which formerly occurred in significant numbers, but are now only scarce passage migrants or vagrants, are Red-breasted Goose (Branta ruficollis), Pallas' Sea-Eagle (Haliaeetus leucoryphus), Sociable Plover (Chettusia gregaria), Siberian Crane (Grus leucogeranus) and Slender-billed Curlew (Numenius tenuirostris).*

In addition to birds, Iran's wetlands host a significant number of endemic plants, fish, amphibians and so on. The inland fish fauna of Iran comprises more than 192 fish species including 166 native and 26 introduced species, and of these, 35 species are endemics (all are members of the 6 families Cyprinidae, Cyprinodontidae, Cobitidae, Balitoridae, Sisoridae and Cichlidae). Some of these occur in unusual habitats, such as hot springs, caves and qanats. *Aphanius ginaonis*, *A. dispar* and *Iranocichla hormuzensis* are only found in several hot springs, while the Iran cave barb, *Iranocypris typhlops* (Cyprinidae) and the blind loach *Paracobitis smithi* (Balitoridae) are restricted to several caves (Esmaeili *et al.*, 2007). Lake Uromiyeh is one of the few saline lakes with an endemic brine shrimp species, in this case, *Artemia urmiana* (Eimanifar & Mohebbi, 2007).

Why do we need to manage wetlands for biodiversity?

As is the case elsewhere, and especially in many arid countries, wetland biodiversity in Iran is under threat and species (and their numbers) are declining. These threats come from both outside and inside Iran. External pressures include global climate change, which may be contributing to reductions in rainfall (drought) witnessed in Iran over the past few years, contributing to dropping water levels in Parishan and Uromiyeh lakes. External pressures also includes hunting (or other disturbance) of migratory bird species that may occur when these species venture outside Iran's territorial borders.

Internal pressures are also apparent, and in Iran these probably represent a more direct and greater threat to wetland biodiversity (see Table 3). These internal pressures include wetland conversion, unsustainable water use, over-fishing, over-hunting, and so on, all of which can lead to rapid decline of wetland biodiversity and even the disappearance altogether of certain wetlands. Tellingly, of the 21 Ramsar sites officially listed for Iran in 2003, seven (7) were listed on the Montreux Record - "a register of wetland sites on the List of Wetlands of International Importance where changes in ecological character have occurred, are occurring, or are likely to occur as a result of technological developments, pollution or other human interference."

Table 3 Examples of key threats to wetlands in Iran

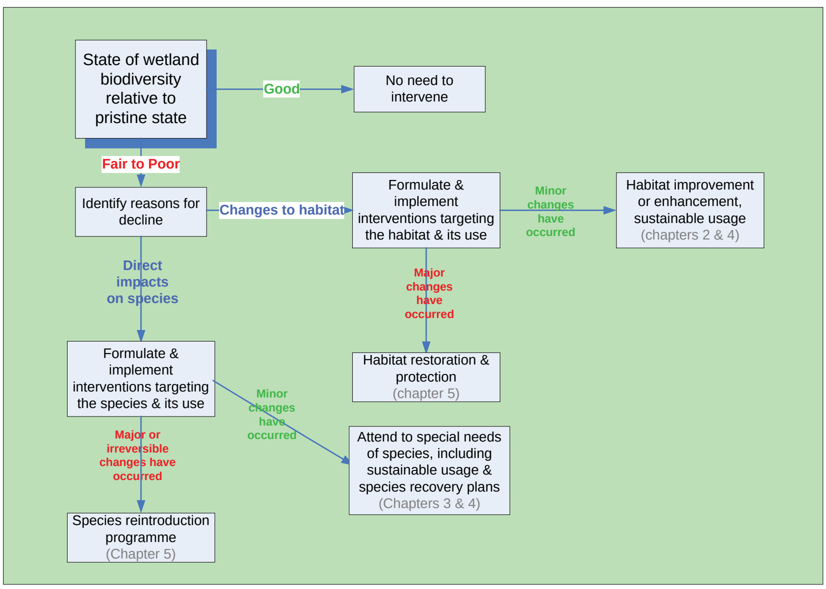
Major cause of wetland degradation	Location	Impacts
Excessive water off-take / water diversion	Lake Uromiyeh	Lowering of water tables Hypersalinity may lead to salt flat formation Decline of species (*Artemia*, flamingo) Impacts on regional climate Economic loss
	Lake Parishan	Lowering of water tables Decline/potential loss of species (e.g. endemic fish species) Economic and cultural impact
Drainage of wetlands	Various satellite wetlands around Lake Uromiyeh	Direct loss of wetland and associated species Economic loss
Tilling for crop production	Lake Parishan & LU satellite wetlands	Modification/disappearance of wetland habitats Loss of sensitive species
Excessive grazing by livestock	Shadegan wetlands & Various satellite wetlands around Lake Uromiyeh	Modification of wetland habitats Loss of sensitive species due to habitat change, trampling of nests, disturbance, etc..
Over-utilisation of fish resources	Lake Parishan	Loss of fisheries production Decline / potential loss of species
Excessive hunting of wildlife	Fereydoonkenar & Other abbandans in Mazandaran	Direct loss of bird species (e.g. Siberian crane) Medium-to long-term economic loss

To prevent the loss of biodiversity, we need to manage the human activities that affect wetlands to sustainable levels, and it is one of the key tasks of the Department of Environment to safeguard the country's biological resources and prevent species loss and (local) extinction. However, many Ministries must also play a role in managing wetland biodiversity, such as Agriculture and Jihad, which manages land use, water and pesticide use and so on, and the Ministry of Energy and Water, which manages water resources.

Set-up of this training manual

Figure 1 provides a flow chart for the types of management interventions required for managing wetland biodiversity – this can vary from 'doing nothing' to reintroduction of species or habitat restoration. The chapters dealing with the various types of management interventions are indicated in the figure.

Figure 1 Interventions in wetlands for managing biodiversity



Linkage with management planning process

The management planning process is cyclic, involving the setting of objectives, formulating actions required, implementing management actions, monitoring and reviewing the management. In the management of wetland biodiversity, various questions need to be addressed during the management planning process, including the following:

Setting biodiversity related objectives:

Maximising or optimizing wetland biodiversity

Is the conservation and protection of key species important?

Do we need to focus on economic benefits of wetland biodiversity?

Which key functions need to be focused on to safeguard biodiversity?

Do we need to raise awareness about the importance of wetland biodiversity?

Formulating actions/interventions:

Is action required, or is maintaining the status quo sufficient for safeguarding biodiversity?

Have wetland habitats changed to a degree that biodiversity is affected, and can this be reversed by undertaking targeted actions (e.g. interventions to promote sustainable use, or enhance existing habitats)? Habitat Recovery Plans may be required, for example, such as the programme for restoration of *Typha* beds at Lake Parishan, or the plans for water allocations for Lake Uromiyeh, both of which form part of the wetland Management Plans.

Are the habitat changes major, and will habitat recovery require significant interventions (e.g. restoration, rehabilitation)? These should be formulated in a Habitat Restoration Plan, which then forms part of the Management Plan.

Have wetland species been affected to such a degree that actions are required to restore populations (e.g. promotion of sustainable use, improving protection or breeding success)? These actions are to be formulated in a Species Recovery Plan, which forms an integral part of a Management Plan.

Has the species (virtually) disappeared from the wetland and is unlikely to return on its own volition, even if habitat is optimised and threats are removed? Then species re-introduction may be required, following strict protocols and follow a clear plan. The Species Re-introduction Plan then forms part of the Management Plan for the wetland.

Monitoring:

Monitoring is to be carried out on a regular basis for implementation of the management plan, (key) species, (key) habitats, human activities in the area, use of wetland products, water quality and quantity, and so on.

Some aspects may be monitored several times a year, while other aspects may be monitored every 5-10 years.

What to monitor and when to monitor depends on the characteristics of the wetland, and the objectives established for the site.

Reviewing management:

Management Plans are finite, and require regular updating. The Management Plans for LU and LP, for example, have “25 year visions”

but require more regular updating.

Managing wetland habitats

Managing wetlands

We can manage wetland habitats for various purposes, for example, for maximizing fish production, for water storage for irrigation or drinking water, or simply for aesthetic reasons to promote tourism. The EU Water Framework Directive – a body of legislation established to manage water resources in the states of the European Union – aims at managing waters to as to achieve “good ecological status” (Table 4). Just what good ecological status is, is explained at length in the various regulations and supporting documents (European Commission, 2005). Under the Ramsar Convention, management aims at Wise Use, and a host of manuals have been issued that highlight this further.

Most wetlands are managed for multiple purposes, including biodiversity, and this is why management plans are required for most sites. The three management objectives for the Management Plan for Lake Uromiyeh, for example, are: i) To raise awareness of the values of the Lake and satellite wetlands and to enhance public participation in their management; ii) Sustainable management of water resources and land use; and iii) Conservation of biodiversity and sustainable use of the wetland resources.

The present section focuses on how wetland habitats can be managed for maintaining biodiversity, and for this purpose it is divided into two parts: i) water quality & quantity, and ii) substrate & vegetation.

Table 4 Ecological status: EU Water Framework Directive

Ecological status classification	Biological Quality Elements		
	Phytoplankton	Macroalgae/ Angiosperms	Benthic invertebrate fauna
High	Undisturbed, normal	Undisturbed, no detectable changes.	Undisturbed. All sensitive taxa present.
Good	Slight change from type specific. No accelerated growth or imbalance.	Slight change from type specific. No accelerated growth or imbalance.	Diversity and abundance slightly outside range. Most sensitive taxa present.
Moderate	Composition, abundance, biomass bloom frequency and intensity moderately differ from type specific conditions.	Composition and abundance moderately distorted from type specific conditions.	Diversity and abundance moderately outside range. Taxa indicative of pollution present. Many sensitive taxa absent.
Poor	Biological communities deviate substantially from undisturbed conditions.		
Bad	Large portions of biological communities are absent.		

Reference: European Commission (2005)

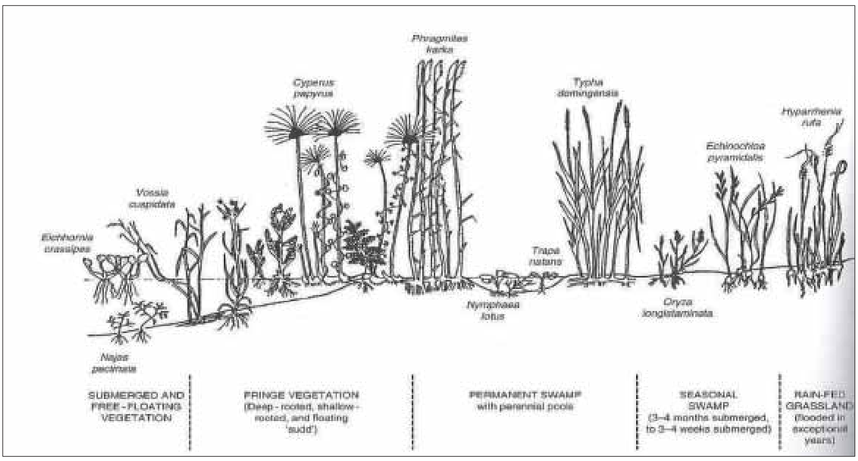
Water quality & quantity

All elements of biodiversity have specific requirements regarding water quantity and quality. Not all species are found everywhere, and each specific wetland type has its own suite of species that are particularly adapted to the given circumstances. This relates to specific tolerance levels (e.g. to salinity, depth or seasonal desiccation), inter-specific competition (why one species does better than another at a given wetland), and the history of a site (why certain species have evolved or been introduced at a particular site).

Water quantity

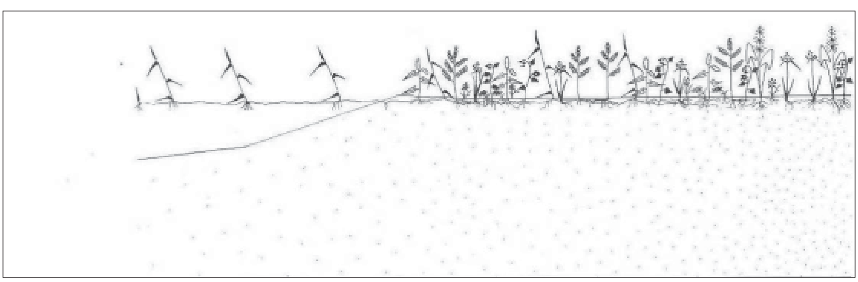
One of the key parameters that determines biodiversity is water quantity, and there are vast differences between a shallow seasonal lake, a deep tectonic lake, a small pond or a vast floodplain. Size, timing and depth matter. In deeper lakes vertical stratification can occur, whereby temperature differences exist at different depths, while in shallow lakes horizontal zonation will be more significant. Larger lakes may have a spatial differentiation and mosaics of different habitats, while small lakes may have only one main type. Plants are adapted to particular water depths (see Figures 2 & 3 of cross-sections of lake or wetland), and different plant life forms are associated with these: free-floating, submerged, emergent, and so on.

Figure 2 Flooding produces characteristic vegetation types in Upper Nile swamps



Reference: Lind & Morrison (1974)

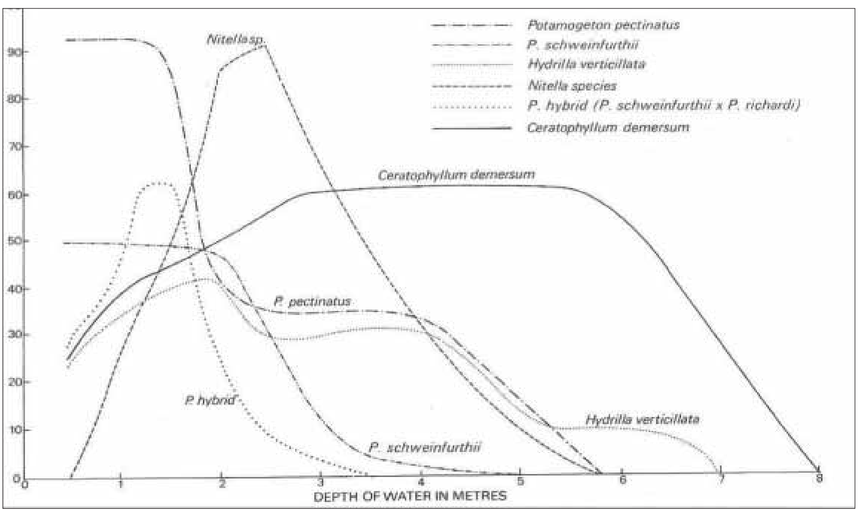
Figure 3 Transect across the edge of Lake Nagugabo, Uganda



Reference: Lind & Morrison (1974)

Plants generally do not have a fixed position, but are adapted to, or tolerant of a range of water depths (Figure 4), and the interplay between species, history and seasonality may determine the zonation of vegetation that arise.

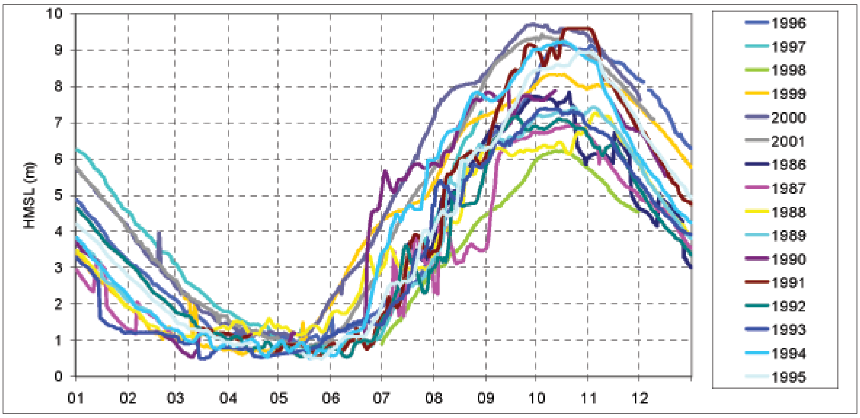
Figure 4 Transect at edge of Lake Bunyonyi, southwest Uganda, showing the zonation of submerged macrophytes



Reference: Lind & Morrison (1974)

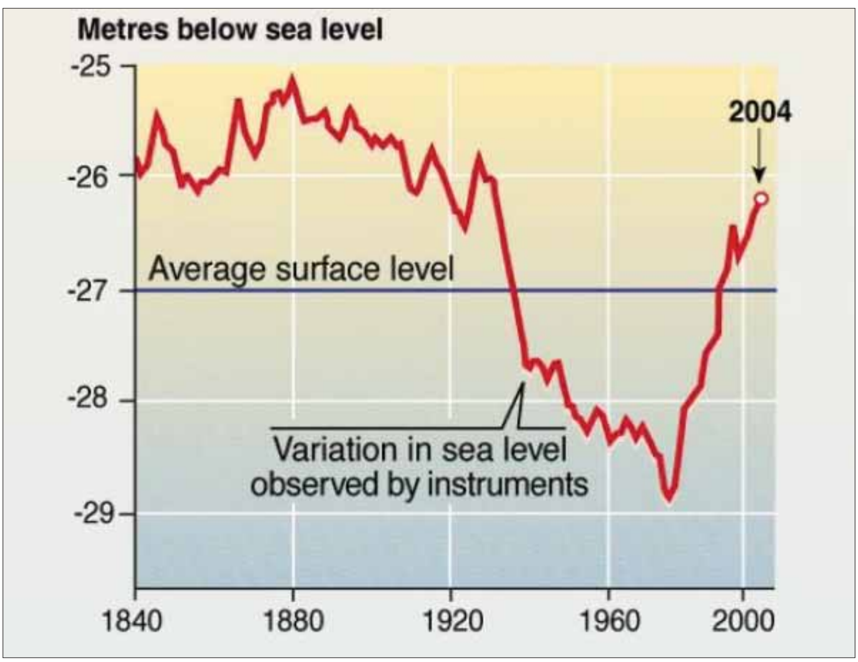
Water quantity is rarely static: on the coast we have daily tidal cycles (diurnal or semi-diurnal), while inland wetlands usually have seasonal or long-term cycles (Figure 5, from Hellsten & Järvenpää, 2002). The seasonal characteristics of the hydrology of a wetland is called the hydroperiod, which may vary from one year to the next, but in natural systems this usually consists of fluctuations around a mean. There may also be long term changes, for example in the Caspian Sea (Figure 6) that are not (part of) a hydroperiod, but may be linked to long-term changes in the basin (e.g. land use patterns) or changes in climate.

Figure 5 Hydroperiod in the Mekong River, Tonle Sap lake



Source: Hellsten & Järvenpää (2002)

Figure 6 Changing water levels in the Caspian Sea, 1840-2004



Reference: http://maps.grida.no/go/graphic/variations-in-sea-level-for-the-caspian-sea-1840-2004

Plants and animals are adapted to hydroperiods and daily tidal rhythyms. If we change daily (e.g. tidal) cycles, for example by constructing a tidal barrier, mangrove trees drown if they are permanently flooded. If we change seasonal cycles, this also affects habitats as inundated trees may die. Wildlife will also be affected, and fish, for example, may fail to spawn if there is no annual flooding cycle.

Dams, reservoirs, weirs and water off-takes directly affect habitats. Dams, reservoirs and weirs deprive downstream areas of water and may even lead to seasonal drying out of riverine habitat, especially in combination with significant off-takes (e.g. for irrigation of crops). Many large rivers world-wide (e.g. Indus River, Pakistan; Yellow River, China; Colorado River, USA; Guadalqivir River, Spain) are now dry in the lower course, at least during several months per year, entirely because of such interventions. Water may be directly extracted from wetlands or from related groundwater (e.g. pumped from lakes, such as at Lake Parishan) and lead to fall of water levels or drying out.

The degradation of wetland systems (rivers, lakes) by water off-takes/dams has lead to the introduction of the concept of 'environmental flows'. According to IUCN (www.iucn.org), environmental flows are the flow regime provided within a river, wetland or coastal zone needed to maintain integrity ('ecosystem health'), productivity and services of freshwater dependent ecosystems. According to the World Bank, environmental flow is the water that is left in a river ecosystem, or released into it, for the specific purpose of managing the condition of that ecosystem.

Environmental flows are rarely determined in a comprehensive way, as this would require full, long-term studies on wetland ecosystems and their hydrology, and this sort of detailed information is rarely available. How much water do we need to allocate to ensure a healthy ecosystem? If near pristine conditions are desired in a river, then 60-80% (or even as much as 65-95)% of the total annual flow may be required to maintain this. In highly developed rivers, environmental flows of about 15-20% of the total average flow (under un-regulated circumstances) may be sufficient to maintain fairly natural conditions. Flows as low as 1-10% of the pre-development conditions are not enough to maintain a healthy river (Davis & Hirji, 2003; Arthington *et al.,* 2006).

Downstream wetlands also have specific needs, and these can be calculated. Lake Uromiyeh, for example, is recharged through 14 rivers with permanent flows and a number of waterways with seasonal flows and occasional floods. Additional sources are direct precipitation and groundwater seepage flows. The average annual inflow into the Lake is estimated at 5300 mcm, which varies between 760 to 15260 mcm, while the total annual water use in the basin exceeds 4700 mcm, of which 94% is utilized for agriculture. To meet increasing demands, several water resources development projects have already been constructed and many others are under construction or planned for future developments. If implemented, this would result in

25% reduction of water inflow into the lake as compared with the present condition. In the present management plan for LU, water allocations have been proposed for the lake, to ensure that it maintains its integrity.

We need to bear in mind that variability is all important for maintaining ecosystems. The magnitude, frequency, timing, duration, rate of change, predictability (of floods & droughts), sequencing, etc…(e.g. pulse release from dam) all determine which species will flourish, and which will not.

Water quality

We are all familiar with drinking water quality standards of DoE and the WHO, and are aware that human health is affected. Likewise, water quality standards of the wetland habitat must also meet in order to maintain biodiversity, as poor water quality will affect wetland species. Various water quality parameters such as salinity, nutrients and toxins all affect water quality and wetland habitats. For certain key species groups (e.g. fish) the water quality requirements have been reasonably well studied (see Table 5).

Table 5 Water Quality criteria for fish

	Harmful	*Poor*	*Good*	*Very Good*	*Excellent*
Suspended sediment (ppm)	>400	400-80	79-25	<25	<25
Conductivity (μmho/cm)	2000-1000	1000-500	500-150	<500	<500
pH	>10.5+<4.0	4.0-5.5	5.5-6.5	6.5-9.0	6.8-8.5
Dissolved oxygen (mg/l)	<1.7	1.7-2.0	2.0-4.0	4.0-5.0	5.0-7.8
Carbon Dioxide (ppm)	100-30	30-25	25-12	<12	<12
Alkalinity (ppm $CaCO_3$ eq) (ppm $CaCO_3$)	<10 <5	10-50 5-12	50-200 12-15	200-500 >15	200-500 >15
Calcium (ppm)	<6.25	6.25-24.9	25-62.5	>62.5	>62.5
Phosphate (ppm)	<0.02	0.021-0.05	0.051-0.1	0.10-0.20	>0.20
Ammonia (ppm)	>1.5	1.5-1.0	<1.0	<1.0	<1.0

Reference: Based on Alabaster & Lloyd (1980)

Salinity

Salinity affects all wetlands, even coastal habitats, as lack of incoming freshwater can affect mangrove species, as many require brackish water and only a few survive in pure seawater. Desiccation in lagoons can lead to (very) high salinities and changes in habitat. Changes in salinity may greatly affect inland wetland habitats – usually an increase due to water off-take (e.g. disappearance of lakes due to hypersalinity; changes in vegetation patterns due to rise in salinity). At Lake Uromiyeh, where the driving factor is reduced inflows, the lake may desiccate and transform into a salt flat if the increase in salinity continues much longer – this has occurred at various other lakes, including Lop Nor in PR China (Figure 7). Off-takes from freshwater lakes may also increase salinities (e.g. Coorong Lakes/Murray mouth Ramsar Site, Australia; Kingsford *et al.*, 2009), which will affect habitats and biodiversity. The opposite may also occur, such as at Chilika Lagoon in Orissa, India, where interventions in the hydrology (an upstream dam) prevented flooding and modulated the flow of the main incoming river. As a result the opening of the lagoon silted up, resulting in a lowering of the salinity of the lagoon, a decline in fisheries production and lower biodiversity (Das & Jena, 2008).

Figure 7 Dried out Lop Nur Lake, PR China

Reference: http://www.how-china.com/wp-content/uploads/2010/10/ear-shaped-Lop-Nor.jpg

Nutrients

Eutrophication (the increase in nutrients, usually N & P) leads to the increase in growth of opportunistic species and loss of sensitive species, and on the whole, to a loss of species although productivity may increase. Most diverse wetlands are often poor in nutrients (oligotrophic), and eutrophication leads to an overall decline in the number of species

The process of eutrophication may lead to i) the uninhibited growth of free-floating species, which may cause anoxic conditions and death of many species; ii) (Harmful) algal blooms: 'algae' that release toxins (e.g. cyanobacteria). Algal blooms can kill, e.g. in freshwater lakes (e.g. many small temperate lakes near towns) and along coasts (Bohai Bay in China, Songhui & Zhou, 2003; Gulf of Mexico, USA, NOAA factsheet3)

The Wadden Sea in the Netherlands, for example, became eutrophic as a result of lots of nutrients entering from the Rhine River from the 1950s to the 1970s. Since the 1970s, the environmental condition of the Rhine improved due to various measures by riparian states and the amounts of incoming nutrients decreased. While good for water quality of the shallow Wadden Sea, the decline in nutrients has lead to a loss of productivity to some extent (Kraan, 2010), affecting cockle fishers and possibly reducing bird numbers.

Toxins

Certain chemicals are known to be particularly harmful in the environment, and these are collectively known as toxins. Many toxins are monitored and WHO/DoE have developed standards for heavy metals (e.g. Hg, Cd, Cr, Pb, etc..), pesticides (e.g. DDT, lindane, carbamates, etc…) and certain industrial compounds (e.g. butyl-Sn, Hg, plastic softeners such as phthalates).

Toxins are often lethal to organisms at low doses, but some toxins may be particularly harmful to certain species(-groups). DDT has been implicated in many harmful effects, but a well documented one is the thinning of egg shells of birds of prey that have accumulated DDT to sub-lethal levels – these eggs are often not viable. In the late 1990s-early 2000s, diclofenac, an antibiotic used by veterinarians, caused the crash of the Asian vulture population that fed on carcases of dead livestock containing doses of this chemical. Likewise, the insecticide imidacloprid has recently been linked to a world-wide crash in honey bee *Apis mellifera* populations, while plastic softeners have been linked to sex changes in fish and amphibians, leading to population crashes, as these substances mimic sexual hormones.

3- http://www.cop.noaa.gov/stressors/extremeevents/hab/habhrca/GoMEX-fact_08-04.pdf

Managing water quantity & quality

The lessons regarding management of water quality and quantity are that we need to manage water quantity in a way that mimics natural conditions (changes), while regarding water quality we probably need to take the precautionary approach, and assume that what affects humans will probably also affect biodiversity.

Substrate & vegetation

Substrate & wetland soils

The bottoms of lakes, rivers and so on are often not considered by wetland managers, but can be crucial. Certain species may require a particular substrate for hiding, burrowing or spawning, and alterations may lead to loss of species. Scouring by floodwaters or by sudden release of water from a reservoir may lead to loss of soft substrate for burrowing (e.g. required by many molluscs). Sedimentation (e.g. due to erosion in catchment) may lead to disappearance of coarse/rocky substrate (e.g. required by certain fish for spawning). Note: incoming sediment may directly smother and kill wetland vegetation and other organisms

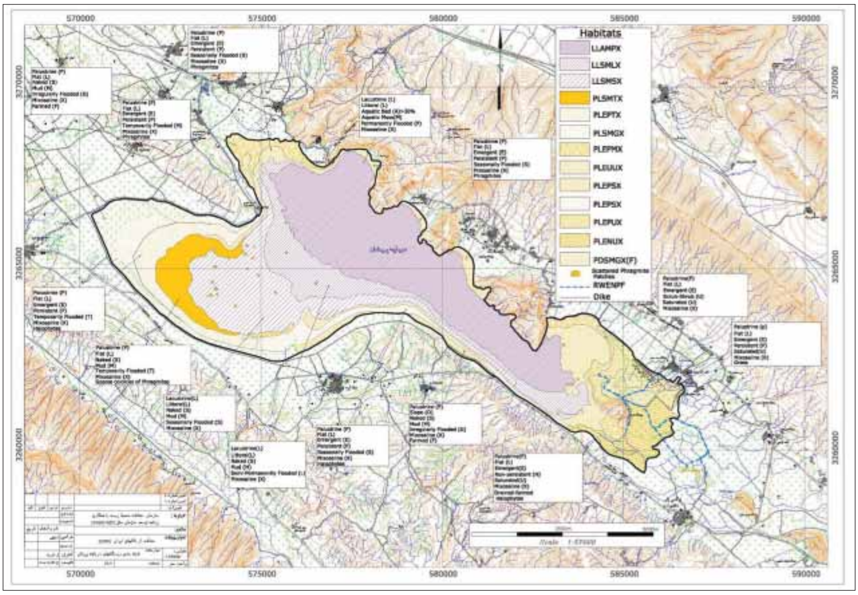
The shores and levees of lakes, rivers and streams also host many species, and changes may affect biodiversity. Steep shores consisting of finer sediments may provide a good breeding habitat for certain birds (e.g. kingfishers, river swallows) and mammals (e.g. otter), while pebbly and rocky islands in the middle of rivers may provide an ideal breeding site for river terns. Replacing such shores with concrete lining results in a significant loss of habitat.

[Peat soils (consisting of partially decomposed organic matter and water) develop in humid environments, from the tropics to boreal regions. They are absent where rainfall is highly seasonal or erratic and low. Highly specific communities may develop in peat soil habitats, but these do not occur in Iran.]

Wetland vegetation

The wetland flora is directly important for biodiversity - Iran has 8,200 plant species in all, almost 2,500 (30%) of which are endemic, some of which are specifically wetland related. In order to monitor vegetation (-changes), it is important to map vegetation, initially as a baseline and repeating this at intervals for monitoring purposes. This has been carried out at Lake Parishan, for example, and is used by DoE in management of the lake (Figure 8).

Figure 8 Vegetation map of Lake Parishan



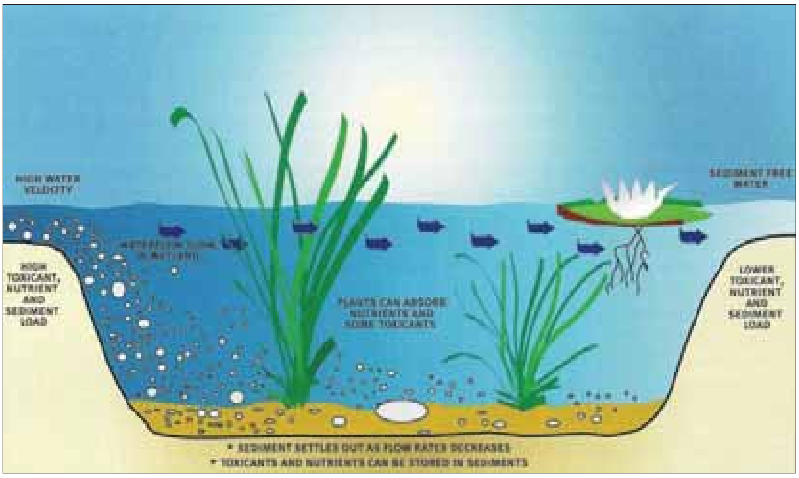
Specific roles of wetland vegetation

Wetland vegetation plays a role in maintaining water quality, as water flowing though a system is purified (Figures 9, 10 & 11) ‘wetlands act as the kidneys of nature’.

Case study

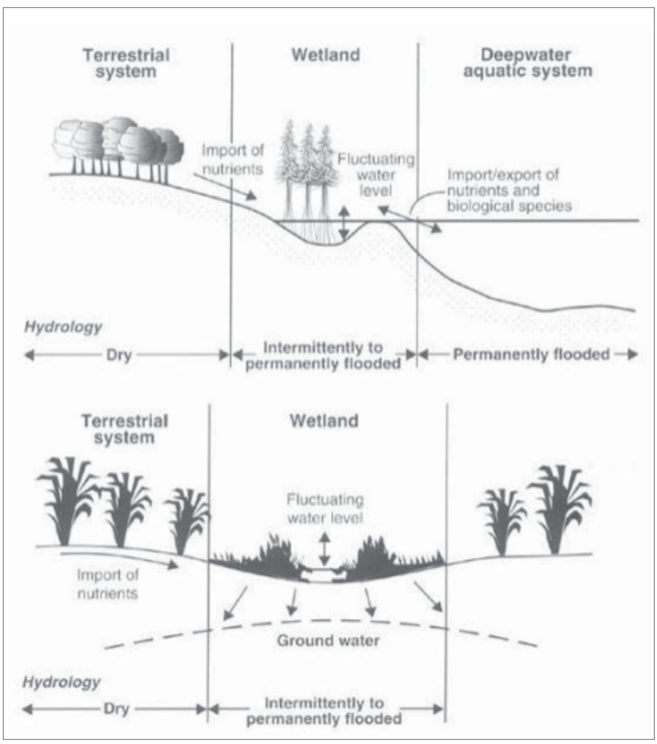
The Buffering Capacity of Wetlands is a sub-component within the Lake Victoria Environmental Management Project (LVEMP) on Lake Victoria, East Africa. Aim of the Buffering Capacity of Wetlands Study (BCWS) is to identify buffering processes and the ability of Lake Victoria wetlands in Tanzania to absorb sediments, nutrients and pollutants. BCWS was carried out by the Dutch consultancy firm ARCADIS Euroconsult in 2000-2001. Three main tasks were carried out: i) Rapid qualitative assessment and prioritization of individual Lake Victoria basin wetlands, and selection of 2-3 study sites for studies of water quality and quantity, and the biological communities (see Figure 12); ii) development of a computerized wetland model that simulates the impact of input loads on wetlands, using data collected at the 2-3 study sites; and iii) using background information obtained, make recommendations on how to carry out a number of wetland studies, including continuation of the field program, and refinement of the wetland simulation model. The study showed that natural wetlands were indeed effective in removing nutrients and sediments (Table 6), quantifying the 'kidney' effect of natural wetlands.

Figure 9 Vegetation influencing water quality



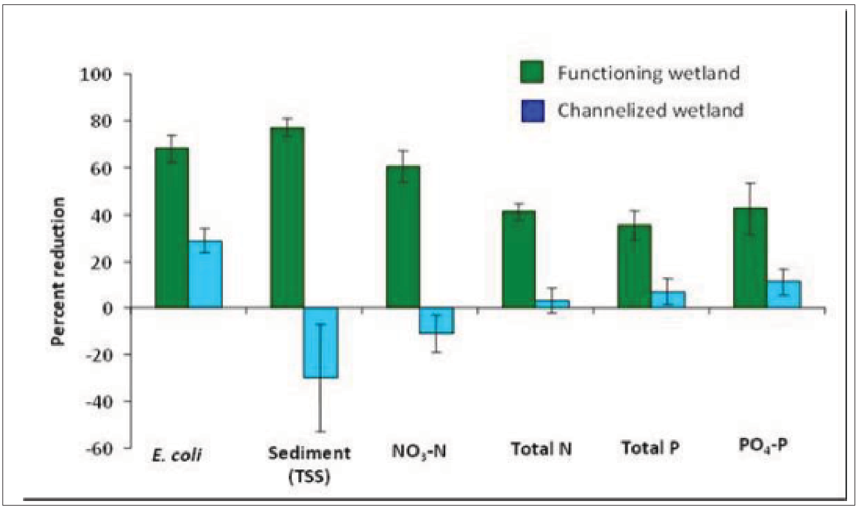
Reference: Davies & Claridge (1993)

Figure 10 Vegetation influencing water quality (2)



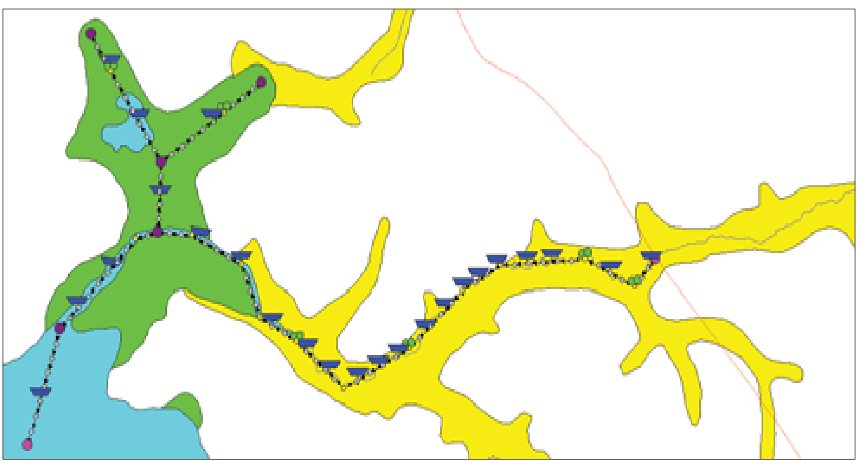
Reference: Mitsch & Gosselink (1986)

Figure 11 Wetlands reducing pollutants



Reference: http://rangelandwatersheds.ucdavis.edu/main/wetlands.htm

Figure 12 Wetlands reducing pollutants in Lake Victoria (2)



Reference: ARCADIS Euroconsult (2001)

Green = Papyrus swamps, yellow = shrubby, seasonal swamp, blue = Lake Victoria; modelled using DUFLOW (see: http://www.mx-groep.nl/duflow/)

Table 6 Influence of wetlands on water quality in Lake Victoria

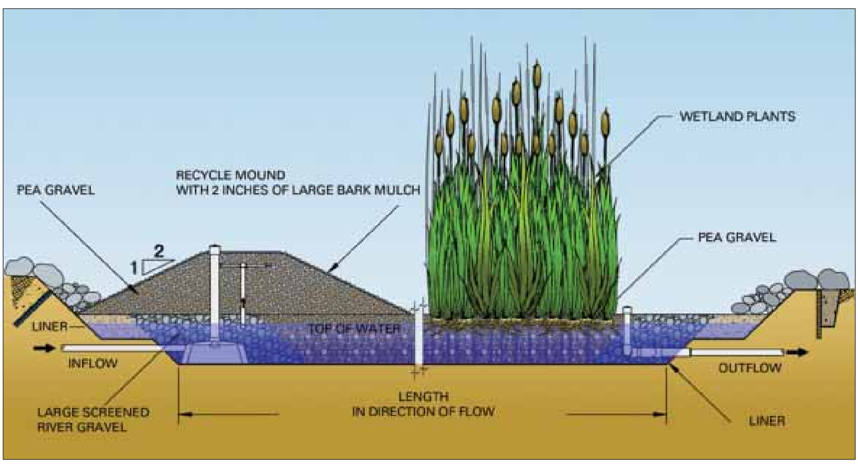
Wetland system	Total P	In-organic P	Ammonium	Nitrate	Total Nitrogen	Dissolved organic matter	Particulate organic matter	Suspended Solids
Nyashishi Seasonal Swamp	5.8	59.8	52.8	-122	-166.9	-342	-202	-42
Nyashishi Permanent Swamp	28.8	92.3	68.8	-79.0	-89.9	-142	-85	+44
Ngono Seasonal Swamp	45.7	63.5	22.1	-34.8	-16	-2.3	-7.6	-2

Reference: ARCADIS Euroconsult (2001); %'s denote percentage removal (+) or addition (-)

Case: Treatment wetlands

Wetland vegetation is used in the construction of so-called "treatment wetlands", i.e. artificial wetlands used to treat polluted waters, for example, from factories or households (Figure 13 shows a schematic example of a treatment wetland). The principle is to increase of surface area (e.g. substrate and plants) for bacteria and fungi to adhere to, and in addition have fast growing plants that are involved in the direct uptake and removal of nutrients (e.g. EPA, 2000; Melbourne Water, 2005).

Figure 13 Treatment wetland (artificial/constructed wetland)



Reference: http://www.natsys-inc.com/media/constructed-wetlands-21.jpg

Role in managing water quantity

Wetland vegetation will retard water flow (by means of hydraulic resistance) in river channels and estuaries, but also along coast. Because of this, vegetation along the coast may attenuate waves and the effects of storms, but also may also increase flooding along rivers as waters are slowed down.

Wetland vegetation may also lead to increased evapo-transpiration from emergent and (to a lesser extent from) floating vegetation compared to open water.

Wildlife habitat

Wetland vegetation plays a vital role in creating wildlife habitat. Emergent vegetation forms resting and nesting sites for birds (e.g. in reeds, trees & shrubs), protection from predators and from the harshness of climate (e.g. shielding against wind). Submerged vegetation may form substrate for spawning of fish and amphibians, as eggs may be deposited on this submerged vegetation. Submerged vegetation may also form an important food supply for fish or diving ducks, or a habitat for small fish and molluscs to shelter in. Aquatic insects are dependent on emergent and free floating plants upon which to settle, and often for feeding on.

Lessons regarding managing substrate & vegetation

Some of the key lessons regarding management of wetland substrate and vegetation are:

Managers need to prevent scouring and sedimentation at wetland sites, as both affect biodiversity.

Natural shores/banks of rivers and lakes are important breeding/resting sites, and modifications (e.g. lining of channels) may eliminate this usage.

Changes in vegetation will indirectly and directly impact associated wildlife biodiversity.

Managing wetland species

Maximizing or optimizing diversity

Wetland managers need to consider whether they need to conserve certain key species (e.g. rare, endemic or otherwise unusual species), or whether their endeavours should aim at maximising the number of indigenous species in the wetland. In most cases the focus will be on key species, as protecting these will often also lead to the protection of a suite of other species.

Habitat changes and diversity

Some habitat change may increase overall biodiversity, for example, the mowing of wet grasslands in Europe, or creation of habitat mosaics may lead to greater diversity in some areas. However, such changes (and disturbance) may affect sensitive species and lead to their disappearance. We need to know the habitat and species assemblages beforehand in order to assess the likely impact of such changes. Significant change will lead to biodiversity loss, and lots of change always leads to impoverished habitats with fewer species.

Impacts of habitat change on biodiversity can be modelled, and a regularly used model for this is GLOBIO3 (van Rooij, 2009; Alkemade *et al*., 2009), which predicts the mean abundance of original species (following a disturbance) relative to pristine conditions. GLOBIO3 uses parameters such as land-use change (agriculture expansion), forestry (management; e.g. harvest system, rotation, etc.), infrastructure and settlement, fragmentation (of habitats), climate change, and nitrogen deposition.

Exotics

A particular type of disturbance that directly affects species is the introduction of alien (exotic) invasive species into wetlands. Often occurring accidentally, and initially resulting in increased species, the effect in the medium to long-term is usually one of species loss. Most alien invasive species are highly competitive, and their proliferation results in the decline or even disappearance of other species. For further information, see "Invasive Species Specialist Group of the IUCN Species Survival Commission" on www.iucn.org.

If the alien invasive is a plant species, this may result in a complete change in the habitat, as original vegetation may de replaced entirely by the invasive weed species. Examples of particularly noxious plant species are:

Giant mimosa Mimosa pigra in Kakadu NP4, Australia, and parts of Indonesia

Water hyacinth Eichhornia crassipes in south and southeast Asia (Tran et al., 2002), Lake Victoria (Mwende & Njoka, 2004)

Salvinia Salvinia molesta in Pakistan, Indonesia and Africa (e.g. Okavango Delta, Mfundisi et al., 2008)

4- (http://www.nt.gov.au/nreta/natres/weeds/find/mimosa/pdf/case_studies.pdf)

Invasive alien animals can outcompete and even entirely eliminate other species, occasionally leading to species extinction. Examples of alien invasive animal species are:

Cane toad *Bufo marinus* in Australia (poisoning of species, outcompeting other amphibians; Urban *et al.*, 2007)

Tilapia species *Oreochromis nilotica* (and to a lesser extent *O. mossambicus*) along east Australian coast (outcompeting fish; FishNote April 2006)

Nile perch *Lates niloticus* in Lake Victoria (extinction of native species; Seehausen, 1999)

Golden apple snail *Pomacea* spp. in Indonesia (native snails)

Zebra mussel *Dreissena polymorpha* in western Europe (outcompeting native species) and North America.

Special requirements for maintaining wildlife biodiversity

Key species often have specific habitat or breeding requirements. A wetland manager may choose to modify the environment to attract or increase numbers of key species, for example, by:

Creating wetlands (!) e.g. man-made abbandans in northern Iran, dams and reservoirs, treatment wetlands

Planting or otherwise encouraging growth of food plants

Establishing or encouraging growth of vegetation important as nesting sites (trees, reedbeds), or constructing artificial nesting sites (e.g. boxes)

Cordoning off areas for disturbance-sensitive species.

A targeted plan for attracting certain key species or increasing their numbers is often called a Species Recovery Plan, as they target species for recovery. An example of how such plans are arrived at is given below, for the ADB-GEF project in the Sanjiang Plains, in the northeastern part of PR China.

Case: Sanjiang Plains, PR China

The Sanjiang Plains lie in northeastern PR China in Heilongjiang province, and are similar to the adjacent Russian far east(-ern Siberia). This area formerly consisted of a large mosaic of reed (*Phragmites australis*) and other swamps, often on peat soils. These were largely drained in the 1970s and 1980s, but were targeted 5-10 years ago for conservation and partial restoration by a large GEF project. Threats were analyzed (Figure 14) and species recovery plans formulated.

For Oriental Stork *Ciconia boyciana* (Table 7), a regional recovery effort based on installation of man-made nest structures at several nature reserves was recommended, while for the Red-crowned Crane, whose nest site selection and productivity depend to a great extent on water levels, a different strategy is therefore required. The Scaly-sided Merganser *Mergus squamatus* prefers larger rivers, a habitat that also supports a nationally protected species, the Mandarin Duck *Aix galericulata*, which is, like the Scaly-sided Merganser, a species that nests in cavities in tree trunks. A recovery plan for Mergansers that would install nest boxes in the wooded riparian habitats of the Wusuli River could increase numbers of breeding Mandarin Ducks in addition to Scaly-sided Mergansers (IRG Group, 2004).

Figure 14 ***Main threats to wetland birds in PR China***

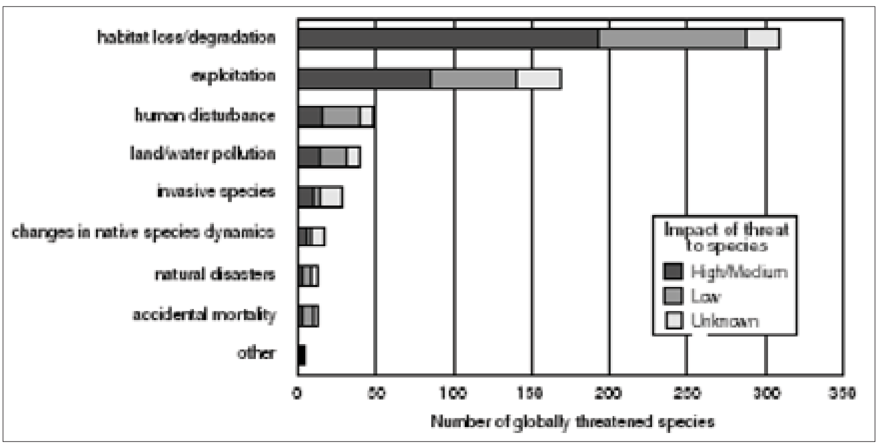


Table 7 Targeting species for Species Recovery Plans

Species or Sub-species	IUCN Sta-*tus	Reason for Selection	Citation
Oriental Stork (Ciconia (boyciana	E	Main threats to species survival are deforestation, wetland drainage and conversion to agriculture, overfishing, and human disturbance, all .of which will be addressed by the SPWPP Protection umbrella covers all fish and all fish-eating birds (herons, egrets, mergansers, osprey, eagles) that will benefit from fish conservation to enhance forage availability for Oriental Storks Occurs in small numbers throughout the Sanjiang Plain during (breeding and migration periods (i.e., it is not locally extinct Nests where suitable trees or other structures are available (nests on power poles, watchtowers, etc. in Russia where human disturbance of (nests is not a factor Highly adaptable to man-made nesting structures, as demonstrated at Honghe and Sanjiang NNRs An Oriental Stork nest project was initiated at Xingkaihu, but did not (achieve targets due to lack of inputs (budget and expertise Listed in Annex I of CITES listed as endangered in China Red Data ,١ Protected in China at Level Book Potential for synergy between recovery efforts in the Sanjiang Plain and those underway with IUCN and GEF support in Russia High visibility of the species and potential “flagship” status as a regional symbol for wetland conservation Excellent species for inclusion in school conservation education projects because children can readily see it and easily count young birds from a distance High potential for development of a regional and trans-border network or association of stork recovery participants	.٢٠٠٠ .IUCN Strategy for the Oriental White Stork (Ciconia boyciana) conservation in Russia. IUCN The World Conservation .Union, Moscow BirdLife International Threatened (٢٠٠١) birds of Asia: the BirdLife International Red Data Book. Cambridge, UK: BirdLife .International

Reference: IRG Group (2004)

Protection of breeding sites

Colonial breeders (e.g. pelican, herons, flamingos) require protection against hunting and human disturbance (including boats and planes), as they are particularly vulnerable. In protected areas, this means that during the breeding season the breeding location is not accessible to visitors through zoning, and staff should only approach the location if their presence is required (e.g. during monitoring), and do so while minimizing disturbance (i.e. no outboard engine or use of radios). As visitors are keen to observe such breeding colonies, observation towers could be constructed at a distance, or strategically placed hides with access routes that can be used unobtrusively.

Protection of key habitats required for breeding (e.g. reeds, trees, rocky substrate) is another management tool. Certain species such as otters, kingfisher and river martins require (soft) sediment cliffs or overhangs in which to excavate burrows for nests, while other species (e.g. river terns) require pebbly islands in rivers, reeds beds (e.g. reed warblers) , or old trees with hollows (tree duck). For some species, the provision of nesting rafts or artificial nest boxes may be very effective.

It is essential that hunting and fishing is controlled during the breeding period (e.g. no fishing during fish spawning period; no hunting during bird nesting period), as hunting and fishing may greatly diminish breeding success and compromise the future population. It can be illustrated that it is in the hunter or fisher's interest to observe such temporary protection, as the population will become healthier and larger in the future.

Case: Danau Sentarum NP

West Borneo, a large floodplain lakes complex (30 lakes) surrounded by swamp forest, very rich in plants and fish resources (Figure 15). There have been no colonial breeding birds for more than 50 years now, athough many of the location names (Danau Sarang Burung, Danau Pulau Burung and Danau Peranak Burung; Giesen, 1987) indicate that there were formerly many colonial waterbirds. According to studies in the 1980s (Giesen, 1987), local communities collected the bird eggs during the breeding season, and this has been unsustainable. Protection of breeding species and the aforementioned locations was recommended, but re-establishment of the colonies had not occurred, even after 20 years.

Figure 15 Floodplain lakes & flooded forest in Danau Sentarum NP

Danau Sentarum NP is located in W. Kalimantan, on the island of Borneo, along the Kapuas River

Case: Lake Tonle Sap, Cambodia

The Tonle Sap Biosphere Reserve in Cambodia – which covers all of the lake plus a significant part of the floodplain – was established by Royal Decree in 2001, and is divided into three zones: core zones, buffer zone and transition zone. In the transition zone, sustainable NRM practices are to be established, while the buffer zone is an area where activities are to be compatible with conservation, in order to protect the core zones. The three core zones are Prek Toal (21,342 ha; Figure 16), Boeng Chhmar (14,560 ha) and Stung Sen (14,560 ha), which were established because of their importance for bird colonies (Prek Toal), bird feeding areas (Boeng Chhmar) and unique gallery forests (Stung Sen). Egg collecting and bird hunting and disturbance remain key threats to the birds at Prek Toal. The Tonle Sap (mainly the Prek Toal core area but also the Boeng Chhmar core area) sustains the most significant colonies of waterbirds in the whole of mainland Southeast Asia. Apart from patrolling, the area is targeted by various awareness programmes with the local communities, and by programmes with the local schools.

Figure 16 Egret at the Prek Toal Core Area, Tonle Sap Biosphere Reserve, Cambodia

Amphibians and chytrid fungii

The chytrid fungus *Batrachochytrium dendrobatidis* has devastated amphibian populations world-wide since the (late) 1990s, some of which have probably become extinct (e.g. golden toad *Bufo periglenes* in Central America, Kihansi spray toad *Nectophrynoides asperginis* in Tanzania, sharp-snouted day frog *Taudactylus acutirostris* in Australia). What caused the introduction of *B.dendrobatidis* and the demise of amphibians? According to some, *B.dendrobatidis* has its origin in Africa and was spread by trade in African clawed toad *Xenopus laevis* – after then, it was probably spread by humans that have unwittingly come into contact with spores (Fisher *et al.*, 2009; Lam *et al.*, 2010).

Case: Kihansi spray toad, Tanzania

The Kihansi Spray Toad Nectophrynoides asperginis (Figure 17) was discovered in the 1990s, just as the World Bank-funded hydropower dam on the Kihansi River was being completed (Figure 18) in the Udzungwa Mountains of Tanzania. The toad occurred in a narrow valley just downstream of major waterfalls, where so-called spray wetlands occurred. After the dam was finished and came into use, spray was mimicked by series of sprinklers that were installed (Figure 19). These worked to some degree in raising humidity, but within several years the toad population crashed and the species went extinct in the wild. Eventually it was discovered that the toad had succumbed to *Batrachochytrium dendrobatidis*.

Figure 17 The Kihansi Spray Toad (*Nectophrynoides asperginis*)

Source:http://endangeredanimalsisaac.webs.com/apps/photos/photo?photoid=94316490

Figure 18 The Kihansi hydropower dam

Figure 19 Artificial sprinklers used to mimic the spray of the (former) waterfall at Kihansi

Migratory species

Migratory species have special requirements because of their seasonal movements. They can be vulnerable along the entire migration route, and require resting, feeding and breeding points along a chain of sites.

Local migrants

Some species migrate over shorter distances only, and although the distinction is arbitrary (there is a continuum), we can term these ‘local migrants’. These local migrants may be:

birds that move along a coastline over the course of a season;

mammals or birds that move up and down a mountain range (e.g. Zagros or Alborz) during the winter/summer;

frogs or toads that migrate from over-wintering sites to nearby ponds or pools in spring;

or fish that migrate up a river to spawn.

The trigger for migration is usually temperatures and/or day length, but for migrating fish the trigger may also be seasonal floodwaters. Important is that barriers are not erected, corridors of suitable habitat remain, and triggers such as floodwaters still occur. Dams may form formidable barriers, but fish ladders (Figure 20) or by-passes can provide an alternative route and reduce the impact on migrating fish. Roads and fences often form barriers for amphibians, and simple 'tunnels' (pipes) leading under a road or fence may serve to lead them safely across. Release of pulses of floodwater from dams may serve as a trigger for migrating fish, while corridors of woodland may be required to encourage and channel the migration of birds or mammals up and down mountain slopes.

Figure 20 Fish ladder (left) at the Minis dam, western Romania

Regional/international migrants

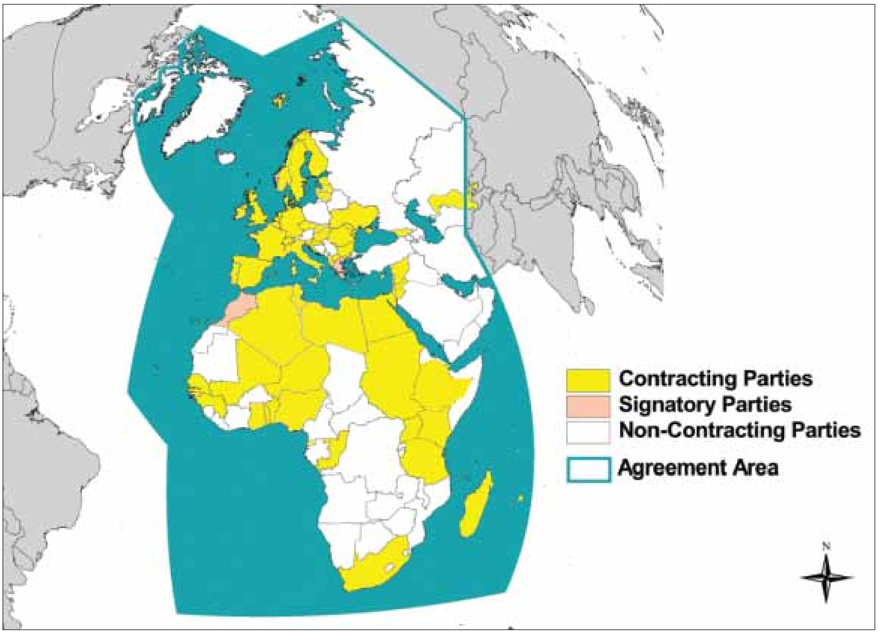
The real migrants in the animal kingdom are certain fish species (e.g. salmon, sturgeon), cetaceans (e.g. whales, dolphins), sirenidae (e.g. *Dugong dugon* dugong), certain butterflies (e.g. Monarch *Danaus plexippus*) and of course a wide range of birds (e.g. many waders, cranes, flamingos, birds of prey). The main difference with the local migrants is that problems and solutions must be addressed at an international level, and that local interventions may not work on their own, if additional interventions are not made elsewhere.

The most comprehensive agreements are under the Convention of Migratory Species (Bonn Convention; http://www.cms.int/), to which 115 countries are a party, including Iran. For birds, international agreements, conventions and covenants have been formulated and implemented to safeguard certain migratory species. The most important of these is the Africa-Europe-West Asian Flyway Agreement (http://www.unep-aewa.org/about/index.htm) – see case below.

Case: AEWA flyway Agreement

The Africa-Europe-West Asian Flyway or AEWA flyway covers the entire African/Eurasian area. This includes all of Africa, all of Europe, South-West Asia (including the Middle East and the Central Asian States), Greenland and the Canadian Archipelago. In total there are 117 Range States (see Figure 21). During a UNEP/GEF intervention from 2003-2008 (*Enhancing conservation of the critical network of sites required by Migratory Waterbirds on the African/Eurasian Flyways*) activities were carried out in 12 key states, and by February 2010 the AEWA Flyway Agreement was signed by 63 states.

Figure 21 AEWA Flryway Agreement & party states



Source: http://www.unep-aewa.org/about/index.htm

Lessons regarding the managing of species

Some of the key lessons regarding the management of wetland species are:

Need to set objectives at onset regarding biodiversity: is this to maximize diversity, or optimize diversity? The latter, may for example, focus on the special needs of certain key or flagship species, rather than maximizing overall diversity.

Need to carefully manage alien species, especially those with an invasive tendency, as these may affect overall wetland biodiversity.

Need to tend to the special requirements of species, e.g. regarding nesting, feeding, resting and foraging. Certain species are susceptible to disease, e.g. amphibians to chytrid fungal infections, and these need to be prevented.

A special case form migratory species, as management must focus beyond the borders of the wetland (or country) in order to safeguard the species.

Managing wetland utilisation

Wetland utilisation

Wetlands have a particular attraction to mankind, and many of the earliest civilisations originated in and around wetlands. Not surprisingly, most wetlands are used by people, in some form or other. In its simplest form there is human access to wetlands, i.e. people entering the wetland (e.g. boating along a waterway), but most forms of utilisation involve using wetland products, such as the use of water, fish or reeds. While access and usage can be fully compatible with maintaining a healthy wetland, some forms may lead to disturbance that in turn may lead to a loss of biological diversity. This chapter will deal with managing wetland utilisation to avoid and prevent loss of wetland biodiversity.

Managing access

The simple presence of people can unintentionally disturb sensitive species. Some plants, for example, are rare and easily trampled, and trodden shorelines can lose such species. Certain wildlife species (certain birds and mammals) may be particularly shy and become so stressed by human presence that they will leave the area. During the breeding season, species may become more sensitive than at other times, and breeding colonies are particularly vulnerable as they may attract visitors who unwittingly disturb the birds. These may in turn may abandon their nests, even temporarily, leading to predation of the eggs and young and lowered breeding success.

Sometimes access needs to be controlled for human safety needs, as some wetland species may be dangerous (e.g. certain jelly fish, crocodiles or hippos), or the wetland itself may pose a danger (e.g. deep quagmires).

Controlling access though zoning is often a first line of defence against unwanted actions by human, such as illegal collecting and hunting (=poaching), or encroachment for agriculture.

There are soft and hard approaches to managing access. Hard approaches include the construction of barriers such as fences, walls or waterways to prevent or at least discourage human entry into a (part of a) wetland. Hard approaches may be further augmented with regular patrolling and policing, as the risk of being caught will deter illegal entry.

Soft approaches involve raising public awareness about the reasons why access to a (part of a) wetland is discouraged or simply not allowed (e.g. to promote breeding success of a particular species). This may be through signage and display boards, or via information provided at a visitors centre or provided verbally by a wetland manager. Providing a reason is usually more effective than a sign that simply states ‘No Entry’. Another soft approach is one whereby the visitor’s movements are guided, for example, along a path or boardwalk that provides easy access, information and shelter. Guiding access often proves very successful, as most visitors will not be inclined to move from this route, especially if this is discouraged by signage and information.

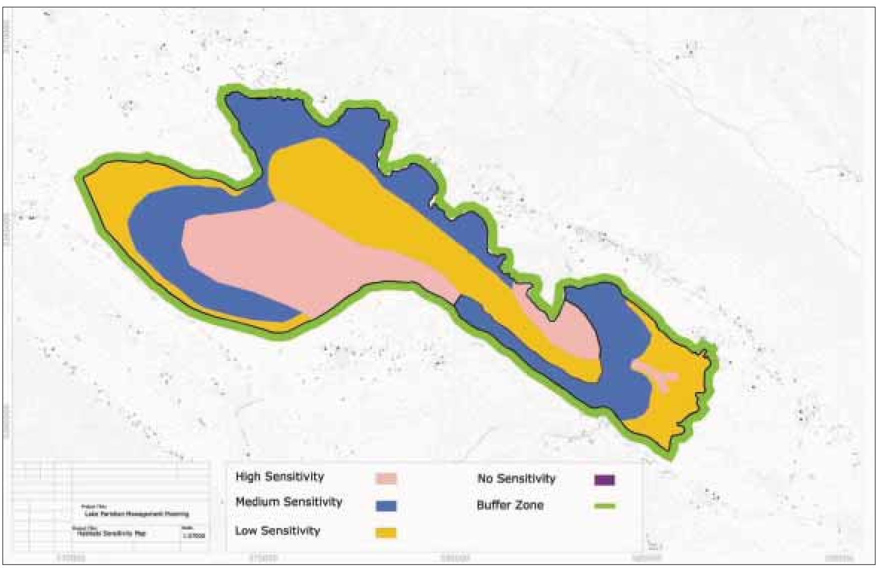
In many wetlands, zonation may be part of the management strategy, and in multiple use areas this may mean that the degree of access is variable in different parts of the wetland. Some areas may be accessible for all, during all seasons, other parts may be accessible only part of the year, while other parts may be off limits all year round. The zonation should be explained and maps displayed (or provided) depicting this, so that visitor’s are aware of the spatial segregation. Zonation needs to be agreed to by all major stakeholders, and usually this requires several rounds of workshops, discussion and negotiations (see case study).

Case: Zoning of Lake Parishan

A series of participatory workshops and community discussion sessions were held during 2007 and 2008 with the aim of developing an integrated management plan for

Lake Parishan. This has been a hands-on interactive process of learning-by-doing, facilitated by CIWP, whereby the main stakeholders worked together to prepare the management plan for which they will have responsibility for implementation in the future. In May 2008 a 2-day workshop was held on 'Zoning for sustainable management'. The aim of this workshop was to draft the Zoning Plan and Codes of Practice for Lake Parishan. Following the workshop, these drafts were subject to wide consultation with stakeholders and user groups, before being finalised and introduced. A wide group of stakeholders participated, including village representatives, fisher folk, farmers, NGO representatives, technical committee members, Kazeroun Council representatives, Fars/Kazeroun DOE staff, DOE National experts, national and international consultants, CIWP Site coordinator – LP and staff of Project Central Office. In the end, a draft zoning map and plan was developed (Figure 22) for incorporation in the overall LP Management Plan.

Figure 22 Zoning map of Lake Parishan



Source: Management Plan for Lake Parishan, CIWP

Access needs to be managed, and there are various aspects that the site manager needs to bear in mind, including:

How to enter? On foot, bicycle, by boat or vehicle. To reduce disturbance, the access route may be covered or fenced off, and the manager may provide a hidden location from which wetland wildlife may be observed. Figure 23 shows a birding hide, from which waterbirds may be observed without disturbing them.

To reduce noise, perhaps only row boats, battery powered boats or canoes may be allowed, and certain items such as radios or loudspeakers not permitted.

Outboard engines on boats can be a particular cause for concern, because of noise, but also because of the waves caused, which can wash away nests and cause erosion from the river or lake banks. Restrictions on speed (or engine size) may help in some cases.

Figure 23 Birding hide at Kakadu NP, Northern Territory, Australia

Use of wetlands & wetland products

“Wetland use” is often about the utilisation of wetland biodiversity, but in this section the use of water is also dealt with, as this often directly impacts wetland biodiversity.

Water

One of the primary uses of wetlands is as a source of drinking water and water for irrigating crops. In many countries, especially those where many people are involved in agriculture in rural societies, the main use of surface water will often be for irrigation purposes, with often 80-90% being used for crops. Many large rivers world-wide (e.g. Indus River, Pakistan, Yellow River, China; Colorado River, USA; Guadalqivir River, Spain) are now dry in the lower course, at least during several months per year, because of off-take for irrigation (and other uses), and associated wetlands have largely disappeared. Water may be directly extracted from wetlands (e.g. pumped from lakes, such as at Lake Parishan) and lead to fall of water levels or drying out.

Case: Dieng Plateau, Java, Indonesia

In the Dieng Plateau in Central Java, Indonesia, a series of small volcanic lakes occur that have been used for centuries as a source of drinking water and for irrigating crops. The latter was originally for subsistence, but a recent move towards market gardening has lead to overexploitation of the resource. Some lakes have dried out completely, while in others (e.g. Telaga Warna) water levels are declining (Figure 24).

Figure 24 Water being pumped from Telaga Warna lake, Central Java, Indonesia

Case: PR China – extraction of irrigation water from Yellow River

China extracts huge amounts of water from the Yellow River, and as a result during much of the year (>8 months) no water flows into the sea and the river is the world's most sediment laden large river (Figure 25). This has in turn lead to coastal erosion and loss of marshlands. Along the central course in the province of Inner Mongolia, irrigation has lead to the large scale cultivation of crops in a former semi-desert area, and the accumulation of (brackish) drainage water has lead to the formation of a large wetland that has over time gained significance by attracting large numbers of waterbirds. However, as China's economy forges ahead at breakneck speed, competition for water was in 2000 already leading to considerations for re-allocation of this water for urban and industrial use, and this man-made wetland is likely to disappear.

Figure 25 Yellow River PR China, the most sediment laden of the world's large rivers

Source: http://www.cctsbeijing.com/china-travel-guide/attraction/images/yellow-river-b.jpg

Harvesting wetland vegetation & plant products

Plants and plant products have long been harvested from wetlands, be it for food (e.g. rice, lotus seeds, waterlily seeds), thatch (e.g. reeds to cover rooves), boats (e.g. from *Typha* or *Papyrus*), construction material (e.g. reeds or willow twigs for walls, wood from wetland trees), mats (e.g. from sedges, reeds), paper (e.g. *Papyrus*), and so on. From early days in the history of mankind, wetlands have been veritable warehouses from which a vast array of products have been harvested.

Case: mangroves in Southeast Asia

Table 8 presents the main direct uses of mangrove plants in Southeast Asia. – apparent is that 77 percent of all mangrove plants have some know use, and that many species have a multiple use. The most common use (41% of all species) is medicinal: mangroves are veritable medicine chests for coastal communities. This is followed by construction material at 25 percent, food (vegetable, spice, fruit) at 22 percent, ornamental use at 17 percent and fuel at (at least) 12 percent. Many minor uses are not tabulated, for example, plants used for making skirts, fruits used in games or as storage vessels, or for making food wrappers.

Table 8 Use of mangrove plant species in Southeast Asia

Mangrove use	Number of species	Percentage
Medicinal	110	41
Construction material	67	25
Food	58	22
Ornamental	46	17
*Fuel	31	12
Utensils	23	9
Fodder	23	9
Tannin	15	6
Oil & wax	11	4
Rope & binding	11	4
Mats and baskets	10	4
Hedges & fencing	8	3
Dye	8	3
Perfume	8	3
Glue	7	3
Roofing & thatching	5	2
No known use	*62*	*23*

Reference: Giesen *et al.* (2007)

While utilisation of wetland plant species is often not a problem nor a threat for wetland biodiversity, over-utilisation or simply harvesting during the wrong season can occur and have negative impacts. Over-utilisation can lead to the direct loss of wetland plant species, and can lead to changes in vegetation or vegetation patterns. Harvesting certain plant resources in the wrong season can lead to loss of breeding areas for wildlife, or lack of seed setting or accumulation of reserve material for adverse seasons. (Self-) regulation of amounts taken, or where/when this is taken can be sufficient for maintaining the resource, key for sustainable exploitation.

Case: Reed harvesting

In Europe, common reed *Phragmites australis* is harvested for traditional thatch of houses. As reedbeds are important for a variety of wildlife throughout much of the year, this generally occurs during the winter months, which has the added advantage that in some areas reeds can be harvested on foot once the wetland is frozen. Reeds are also used in restoration of wetlands in parts of Europe, where it has the advantage of being able to recover some of the investment costs required for restoration, and convince local politicians.

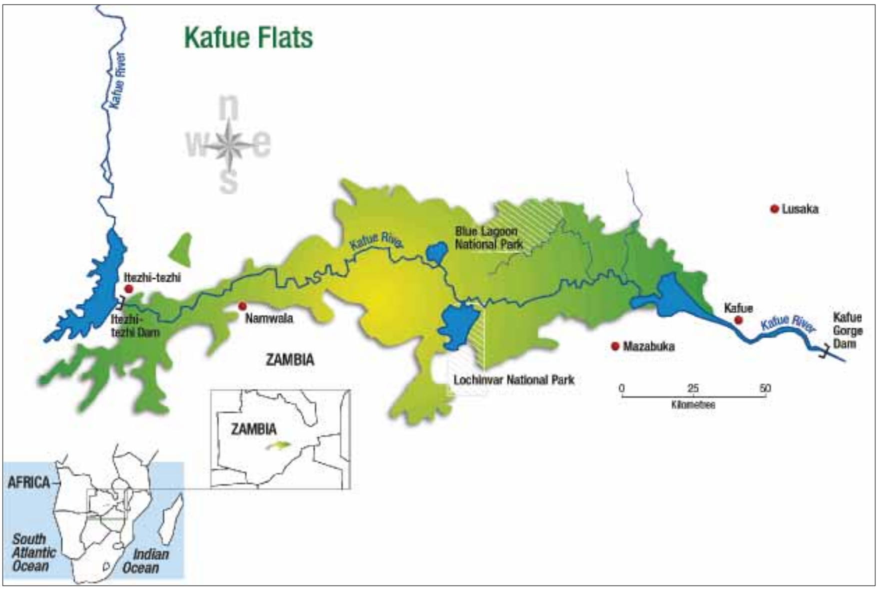
Grazing

Wetlands are often used for grazing, as many wetlands provide good fodder along margins, but also as waters recede. The Shadegan wetlands in Khouzestan, for example, are intensively utilised for cattle grazing by the local community. In arid areas, wetlands may provide the only source of forage for many species, including wildlife (e.g. Lewa, Kenya; www.lewa.org) and livestock (e.g. Shandur & coastal Pakistan). However, there is always the danger of overgrazing, which can lead to changes in vegetation, loss of fodder value, and so on. Grazing livestock can disturb wildlife, trampling nests or opening closed vegetation required by some. Grazing needs to be limited to what the system can withstand (‘carrying capacity’).

Case: Zambia: Kafue flats

On the Kafue flats in Zambia, southern Africa, which is a very vast season wetland area (Figure 26), grazing controlled by the Latunga (king), who annually announces when grazing may commence on these plains. This has been the case for centuries, and the Latunga has absolute power in this. Over the years, it has been an effective way of managing the resource and preventing over-utilisation.

Figure 26 Kafue flats, Zambia



Refererence: http://assets.panda.org/img/original/kafuemap.gif

Fishing

Fishing is one of the most common uses of wetlands world wide, and this has a history that goes back to the dawn of mankind. Fishing of shellfish or finfish is carried out for basic subsistence, by commercial fisheries and for recreational purposes. People use a vast array of fishing gear and approaches, and these can be very effective, as it is often possible to (nearly) completely remove a species from the wetland if this is not regulated in some way. Without regulations, the resource is easily depleted, resulting in a direct loss of biodiversity. Overfishing leads to disappearance and (local) extinction, with numerous examples worldwide (e.g. dwindling stocks of salmon *Salmo salar* in Europe and parts of North America, sturgeon in Iran and Russia (e.g. *Acipenser gueldenstaedti*), orange roughy *Hoplostethus atlanticus* in Australia, South Africa and New Zealand, giant Mekong catfish *Pangasianodon gigas* along the Mekong River).

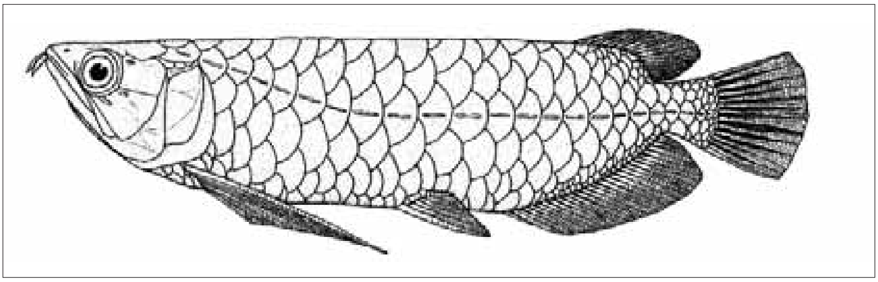
In traditional societies, community based regulations (i.e. self imposed) often exist and are often very effective, having been formed over a long time and based on empirical results. Community based regulations, however, work as long as communities are not too large relative to the resource (or have alternatives), and as long as all members respect the communal regulations. Things often fall apart if the resource becomes open-access, and outsiders lay claim to the resource, resulting in competition and over-utilisation.

Externally based regulations (e.g. via enforcement/management via Fisheries Departments) may be imposed to regulate fisheries, especially when community regulations are no longer adhered to or when the resource is dwindling, and this approach is nowadays more common than traditional regulation.

Case study: Asian Arowana: West Kalimantan

The Asian Arowana *Scleropages formosus* or Asian Bony-tongue (Figure 27) occurs throughout Southeast Asia, and is highly prized as an ornamental (dragon fish), especially the red variety that only occurs in the black, peaty waters of inland West Kalimantan (Indonesian Borneo). As the red Asian Arowana became rarer in the wild due to over-harvesting (it was attracted by lamps at night), the value of the species rose to more than USD 1000 per fish in the 1980s. This represented more than a whole year's income for an average fisher, and fishing pressures rose even further, leading to near extinction in the wild. Captive breeding was tried, but proved unsuccessful for many years, in spite of various trials by fisheries department and private companies. Finally, it was discovered that water depth was key for this mouth brooding species, and following IUCN intervention in the late 1980s, local companies were able to successfully breed the species. This lead to a drop in fishing pressures and ultimately in prices, and successful recovery of the wild population.

Figure 27 Asian Arowana *Scleropages formosus*



Reference: http://www.natuurwetenschappen.be/en/institute/associations/rbzs_website/bjz/back/pdf/BJZ%20137(1)/137_1_89_97html/Volume%20137(1),%20pp.%2089-97.html

Case 2: Eider duck and cockle fishing in Wadden Sea

Eider duck *Somateria mollissima* utilise the Dutch Wadden Sea during the winter months, and a sizeable part of the European population depends on these shallow coastal waters. For feeding, these diving ducks are dependent on molluscs (esp. cockles *Cerastoderma edule* and mussels *Mytilus edulis*). In 1990 the mussel population collapsed due to overfishing, and when the cockle industry expanded over a decade ago, this lead to a decline in these molluscs and a sharp dive in eider duck numbers.

Hunting & harvesting wildlife products

Hunting of water birds (e.g. ducks, coots), amphibians (esp. frogs), reptiles (e.g. turtles, crocodiles) and mammals (otters, beaver, wild boar, Kafue lechwe) is widespread, for subsistence, sale or recreational purposes. As with fishing, when small scale and local, this can be self regulated, but open access often leads to over-exploitation and (local) demise or even extinction, unless heavily regulated in another form.

Wildlife products can also be harvested in wetlands, such as eggs (e.g. from waterbird colonies) and honey (in forested wetlands). (Self-) regulation is highly important, as such products are easily over-exploited, resulting in disappearance of waterbird colonies and loss of bee colonies. There are many examples of where this has gone wrong, and where colonies have disappeared or moved.

Case: Self regulated honey collection, Danau Sentarum NP.

Local community members place boards (locally called *tikung*; see Figure 28) in trees as a place for Asian migratory bees, *Apis dorsata*, to place their hives, which occurs on a seasonal basis and not all year round. These tiking are marked by their owners, who are allowed to harvest the honey from any hive constructed on one of their boards. There are rules about what can be taken, and the top-most 1/3 is left on the board, as this is where most of the brood is present, needed for maintaining the bee population.

Figure 28 Placing a 'tikung' in a tree at Danau Sentarum NP

Reference: http://assets.wwfid.panda.org/img/memasang_tikung_small_19320.jpg

Case: Fereydoonkenar, Mazandaran, Iran

The typical wetlands of this area are artificial or man-made wetlands. To be more precise, these wetlands are in fact agricultural fields (paddy fields) that go under rice cultivation during spring and summer and become flooded by rivers and streams in autumn and winter and reserve different quantities of water due to their size and depth. Within these wetlands, privately owned 'damgahs' occur, where the owners harvest waterfowl by traditional means, including series of traps and nets (Figure 29). These waterfowl – mainly duck species – are sold on the local markets for food and are a lucrative additional source of income for local land owners.

Figure 29 Tame ducks are used to lure wild ducks in *damgah* at Fereydoonkenar

Lessons regarding wetland utilisation

Some of the key lessons regarding wetland utilisation are:

Utilisation of wetlands and wetland species is rarely the major threat to a wetland, and economic benefits derived from a wetland help in securing its protection as it is seen as being of value. Over-utilisation is what needs to be prevented, and the key is therefore sustainable utilisation, and using low impact forms of utilisation.

Water allocation for wetlands is essential in order to maintain wetland functions; this can be in the form of (formal) environmental flow allocations in the case of dams/ reservoirs, but also limits on off-take from rivers and groundwater.

Plant and vegetation collection/harvesting, grazing, fishing and hunting can often be carried out sustainably, but this requires establishing and agreeing upon what levels are sustainable, and putting a mechanism in place for ensuring that these are adhered to. This can be via informal agreements between stakeholders, but more often more formal arrangements will be required that are recorded in site management plans, and include methods of enforcement.

Zoning is a very valuable tool in managing utilisation and disturbance.

Assisted recovery of degraded wetlands & wetland species

As mentioned in Chapter 1, when wetland habitats are too degraded to recover with limited assistance or intervention by site managers, then habitat restoration may be the preferred option in order to maintain biodiversity. Similarly, if species populations have dwindled to levels from which recovery by means of limited assistance is no longer possible, then species reintroduction may be required. In special cases, species introductions may be carried out to create separate (safe) populations of endangered species.

Both habitat restoration and species reintroduction should not be treated lightly, and should be seen as last resort measures, as they are not without risk, and are often expensive options as well. Habitat restoration is dealt with in 5.1, and species reintroductions in 5.2. As plant species are habitat forming (they form vegetation, which is a habitat for wildlife), plant reintroductions are dealt with in 5.1.

Habitat restoration

Habitat restoration has many (largely similar) definitions, two of which are: i) The return of a habitat to its original community structure, natural complement of species and natural functions. (Babylon Dictionary; http://dictionary.babylon.com) and ii) the act, process, or result of returning a degraded or former habitat to a healthy, self-sustaining condition that resembles as closely as possible its pre-disturbed state (Gov. Massachusetts5).

Examples of habitat restoration include removing of contaminated material from a wetland, increasing tidal flow to a wetland cut off from the sea, re-establishing of near natural river flow, replanting of mangroves where these have disappeared, enhancing degraded seafloor habitats, erosion control and treating runoff to improve water quality, and managing invasive species.

In practice, habitat restoration at a given wetland will often involve various types of restoration, that all focus on improving the health of the wetland ecosystem. Key is that the initial threats are (largely) removed before beginning the restoration activities, otherwise wetland restoration will be a poor investment.

In reality, however, restoration involving the returning of a system to the pre-disturbance pristine state is in most cases unattainable, and the best that can be

5- http://www.mass.gov/?pageID=eoeeaterminal&L=4&L0=Home&L1=Air2%C+Water+26%+Climate+Change&L2=Preserving+Water+Resources&L3=Water+Habitat+Restoration&sid=Eoeea&b=terminalcontent&f=eea_water_habitat_restoration&csid=Eoeea

achieved is wetland rehabilitation, whereby most of the former characteristics and functions are returned. As the term 'restoration' is more commonly used, this will be used here, although rehabilitation is what is meant. Restoration of various broad wetland types all have their own approach, peculiarities and typical problems encountered, hence this introduction to wetland habitat restoration briefly deals with the following habitat types:

Lagoons

Coastal marshes and mangroves

Seagrass beds

Streams and rivers

Freshwater lakes

Riparian- and swamp forests

Lagoon restoration

Lagoons are shallow bodies of water, often separated from sea by sandbars or (less commonly) coral reefs. Lagoons are brackish bodies of water that are connected to the sea, but also have a regular freshwater input from incoming rivers and streams. The main problems facing lagoons are often:

Pollution (as these bodies are near-closed, at least seasonally; e.g. Puck Lagoon, Poland which received raw sewerage).

Lagoons may become excessively freshwater if the connection to the sea becomes closed off (e.g. due to a lack of flooding of the incoming river, as the case in Chilika Lagoon in Orissa, India, where interventions in the hydrology (an upstream dam) prevented flooding and modulated the flow of the main incoming river. As a result the opening of the lagoon silted up, resulting in a lowering of the salinity of the lagoon, a decline in fisheries production and lower biodiversity (Das & Jena, 2008).

Lagoons may silt up, if flushing is limited and incoming waters are silt-laden.

Remedial actions to restore lagoons include:

Treatment of incoming waters and erosion control.

Seasonally breaching the blockage of the connection with the sea.

Water allocation for the lagoon, including provision of a peak flood to breach the sand bar (or other natural blockage).

Case: lagoon on Sri Lanka's east coast

Many lagoons dot the coast of Sri Lanka, but many have become degraded due to pollution and a lack of incoming freshwater, which results in reduced fish catches in these formerly productive waters. In order to mimic the annual breaching of the sandbar, fishermen in local communities invest time and labour in excavating channels so that an exchange of waters is once again possible (Figure 30).

Figure 30 Breaching a sandbar to reconnect the lagoon with the sea

Coastal systems: mangroves

Restoration or rehabilitation of mangroves is often recommended when the ecosystem has been altered to such as extent that it cannot regenerate naturally. However, the concept has not been analysed or discussed much in mangrove literature, and as a result, those managing mangrove restoration frequently emphasize planting of mangroves as the primary tool in restoration (Lewis & Streever, 2000). Mangrove habitat can regenerate naturally in 15-30 years if: i) the normal tidal hydrology is not disrupted, and ii) the availability of waterborne seeds or seedlings (propagules) of mangroves from adjacent stands is not disrupted or blocked. If hydrology is still (near-) normal, but influx of seeds or seedlings is disrupted, then mangroves may be successfully established by planting (Lewis & Streever, 2000).

In order to achieve successful mangrove restoration, the following five critical steps need to be taken:

Understand the autoecology (i.e. individual species ecology) of the mangrove species at the site, in particular the patterns of reproduction, propagule distribution, and successful seedling establishment.

Understand the normal hydrologic patterns that control distribution and successful establishment and growth of targeted mangrove species.

Assess modifications of the original mangrove environment that currently prevent natural secondary succession.

Design the restoration programme to restore appropriate hydrology and, if possible, utilise natural volunteer mangrove propagule recruitment for plant establishment.

Only utilise actual planting of propagules, collected seedlings, or cultivated seedlings after determining (through steps i-iv) that natural recruitment will not provide the quantity of successfully established seedlings, rate of stabilisation, or rate of growth of saplings established as objectives for restoration (Lewis & Streever, 2000).

Case: Mangroves in Aceh province, Sumatra: Green Coast project

The devastating tsunami of 26 December 2004 caused a great loss of human life in Aceh province, on the northern tip of Sumatra island, Indonesia. At the same time, the force of these waves were so great that many mangroves were also totally destroyed, and many projects were established to restore these habitats that are so vital in coastal protection, but also for coastal fisheries. One of the main programs was the Green Coast program carried out by Wetlands International from 2005-2009, in many of the coastal villages, in cooperation with local villagers (Figure 31). Although largely successful, problems encountered were: i) some areas were so altered by the tsunami that they were no longer suitable for mangroves (e.g. too high and dry due to sand deposition); ii) fish farmers had established brackish water fish ponds in some areas targeted for restoration; and iii) some restored areas were later destroyed by infrastructure programs (e.g. road or causeway construction).

Figure 31 Replanted mangroves at Gampong Baru, near Banda Aceh, May 2009

Seagrass beds

Seagrass beds have been under threat for decades, and loss of various formerly productive seagrass beds have led to numerous restoration programs. Van Katwijk *et al.* (2009) reviewed scientific literature and 20 years of seagrass restoration research for the Wadden Sea (shared by the Netherlands, Germany and Denmark), evaluated traditional guidelines and proposed new guidelines for seagrass restoration. In all cases, reintroduction of seagrass to a site was required, either in vegetative form or as seeds. Van Katwijk *et al.* (2009) conclude that:

Habitat and donor selection are crucial: large differences in survival were found among habitats and among donor populations. The need to preferably transplant in historically confirmed seagrass habitats, and to collect donor material from comparable habitats, were underlined by our results. The importance of sufficient genetic variation of donor material and prevention of genetic isolation by distance was reviewed.

The spreading of risks among transplantation sites, which differed in habitat characteristics (or among replicate sites), was positively evaluated. The importance of ecosystem engineering was shown in two ways: seagrass self-facilitation and facilitation by shellfish reefs. Seagrass self-facilitative properties may require a large transplantation scale or additional measures.

Similar conclusions were reached by Paling *et al. (2009), who carried out a* *worldwide review of seagrass restoration activities.*

In general, the results are mixed, and in many instances restoration of seagrass beds has failed in spite of significant investments made. This may be because the underlying threat was not fully appreciated or understood, or simply because of the plants succumbing to events (e.g. storms, disease, predation, freezing). Certain species, such as Zostera noltii, are notoriously fickle, responding poorly to attempts at replanting (Van Katwijk et al, 2009; case study below).

Case: Transplantation of seagrass *Zostera noltii* in the Netherlands

Much of the southwestern part of the Netherlands province of Zeeland lies below sealevel, and are shielded from the sea by a series of dikes that are scheduled to be upgraded in the coming years. Small seagrass *Zostera noltii occurs in the waterways of the Oosterschelde, a brackish area that is a Natura2000 protected area. The species has declined since closure of this intertidal area in the mid-1980s, from 1200 ha in 1980 to under 100 ha in 2008. As this species occurs in the intertidal zone, dike upgrading activities will affect stands of seagrass close to the dike, so a program was undertaken from 2007-2012 to transplant Z. noltii from areas where they will be affected to nearby, suitable sites. Various techniques have been tried (Figure 32), including pretreating the sediment to reduce lugworm Arenicola marina burrowing activity, different planting densities, timing, and so on, but results have been mixed to disappointing. Recent evidence is emerging that replanted areas may be affected by brent goose Branta bernicla, who feed on Zostera rhizomes and whose population has increased significantly over the past decade. Also, whereas these geese formerly were mainly present in the autumn, winter and early spring, part of the population now resides in this part of the Netherlands all year round.*

Figure 32 Transplantation of *Zostera noltii* at Krabbenkreek Noord, May 2010

Streams and rivers

Human influence has affected the natural form, flow and function of many streams and rivers, and as a result most rivers are far from natural. The main human impacts include pollution, modifications of the channel, and water offtakes (e.g. via dams, reservoirs, weirs). In the 1980s the realisation grew that these changes were impacting functions and values of rivers, and that river biodiversity was being depleted. As a result, river restoration programs were initiated to return river channels to a more normal situation (e.g. adding formerly removed meanders), reduce pollution entering streams and rivers, and allocating water to preserve river functions (e.g. environmental flows). Part of this is already dealt with in 2.2.1 on water quantity and 2.2.2 on water quality and won't be repeated here. A special case worth mentioning is the water allocation ongoing along with Murray River in Australia, under the governmental program "Water Allocation Plan for the River Murray Prescribed Watercourse".

River morphology is an aspect that still requires attention, and will be dealt with further. In Northern America, Europe and Australia, re-meandering of river courses has been carried out since the 1990s (Eiseltová & Biggs, 1995), mainly in attempts to re-establish former biodiversity in areas that have lost much of their natural habitats (Figure 34).

Case: Room for the river program, The Netherlands

In the early 1990s the Netherlands experienced several major floods, including one whereby 200,000 people had to be evacuated. As a result, the "Room for the River project" was initiated which encompasses four rivers: the Rhine, the Meuse, the Waal and the Ijssel. Under this program, these rivers will literally be given more room, to reduce risks of flooding. The program includes the following components:

Relocation of dykes: Dykes will be relocated farther from the river shore. This will create additional space within the flood plain for the river during annual floods.

Lower the level of floodplain. In addition to the relocation of the dykes, the floodplain bottom will be lowered in depth. Increasing the depth in the floodplain must occur due to the collection of sediments in the area after years of regular flooding.

Reduce height of the groynes. Groynes within the riverbed will be lowered to allow for more drainage to occur during an increase in water levels more quickly than presently positioned. Groynes will be added in specified locations in addition to the modifications occurring to the existing structures.

Construction of a "Green Channel" as a flood bypass around Veessen-Wapenveld.

Increase the depth of the side channels. Side channels will be lowered in depth to increase the barrier between the river and infrastructures and residents. It will also allow for more water to be removed from the flooded location thus reducing the breach of the dykes.

Removal of obstacles.

Case: Oude Ijssel River, The Netherlands

The Oude Ijssel River in the eastern part of the Netherlands is a former channel of the Rhine River (several thousand years ago), that was used for navigation and transport of goods for many hundreds of years. Since the 1800s, the channel has been modified and straightened, peripheral seasonal wetlands drained and converted to agriculture (and pasture), and sluices added to manage water levels. Also, pollution was a major problem, especially in the 1960s and 1970s. As a result, many species disappeared and the river was in a poor state. In the 1980s and 1990s, a clean-up programme has been successful in vastly improving water quality. In addition, over the past decade, fish ladders have been installed (retro-fitted) into dams and sluices, and peripheral wetlands created (Figure 33). Since 2000, species have returned, including breeding pairs of the common kingfisher

Alcedo atthis and a healthy population of catfish Silurus glanis.

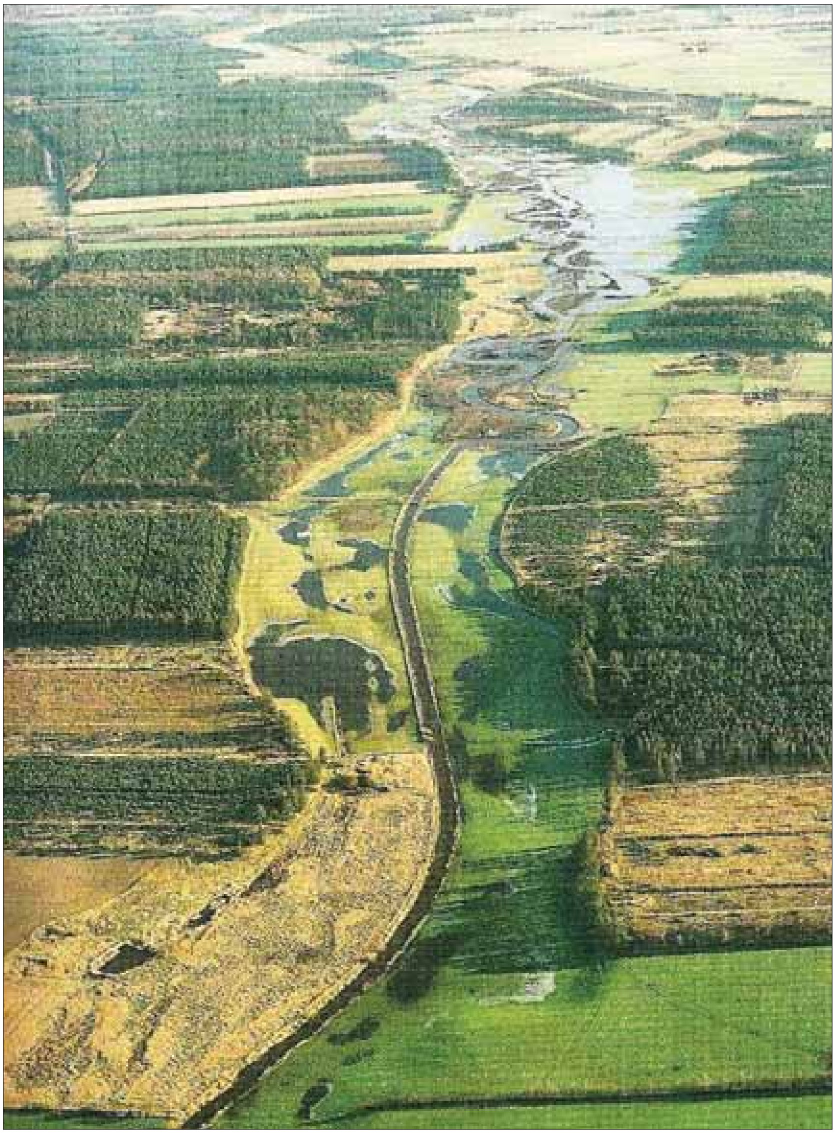
Figure 33 Oude Ijssel River restoration

Current river (a), sluices with fish ladder (b), peripheral wetland under construction (c) and already restored peripheral seasonal wetland (d)

Case: Four Major Rivers Restoration Project, South Korea

The Four Major Rivers Restoration Project of South Korea is the multi-purpose green growth project on the Han River (Korea), Nakdong River, Geum River and Yeongsan River. This restoration project will provide water security, flood control and ecosystem vitality. This project was first announced as part of the "Green New Deal" policy launched in January 2009. The Project has five key objectives: 1) securing abundant water resources against water scarcity; 2) implementing comprehensive flood control measures; 3) improving water quality and restoring ecosystems; 4) creation of multipurpose spaces for local residents; and 5) regional development centred on rivers. More than 929 km of national streams will be restored as part of the Four Major River Restoration Project. A follow-up project will be planned to restore more than 10,000 km of local streams. More than 35 riparian wetlands will also be reconstructed (http://en.wikipedia.org/wiki/The_Four_Major_Rivers_Project).

Figure 34 Re-meandering of Brede River, near Løgumkloster, Denmark



Adapted from Eiseltová & Biggs (1995)

Freshwater lakes

The main human-induced stresses affecting freshwater lakes are pollution and excessive water offtake, and restoration attempts therefore focus on water quality improvement and water allocation (Klapper, 2002). Additionally, conversion of lake shores and sedimentation are also a major problem in some lakes that require attention in restoration programs. The main interventions in restoration programs involve:

Reduction of incoming nutrients, by urban and industrial waste water treatment and erosion control.

Reduction of sediment input by putting erosion control measures in place. Alternatively, lake beds may be dredged to remove excessive accumulated sediment (Murphy *et al., 1999; City of Delafield, 2008).*

Water allocation, by reaching agreements between users, formulating a plan of implementation, and putting a system of enforcement in place. Key mechanisms and principles are discussed by Dinar et al. (1997).

Lake shore restoration is largely one whereby conversion of lake edge vegetation to agriculture needs to be managed to preserve key habitats (e.g. at Lake Parishan, but also around Lake Victoria in East Africa, which is important for maintaining water quality of the lake).

Most of these programs are costly, and prevention of lake degradation is a much more cost-effective option, if early signs of degradation (e.g. increased nutrient levels, dropping of lake levels) are heeded.

Case: Azraq wetlands, Jordan

The Azraq wetlands are located in eastern Jordan, in a desert area. It is a very important oasis wetland for migratory birds and also has at least one species of endemic fish. Uncontrolled off-take of groundwater (with many hundreds of pumps for agriculture) has devastated the wetland (a Ramsar site), leaving only a few % of the area. The Jordanian Royal Society for the Conservation of Nature initiated a GEF-UNDP funded project to restore the wetland, but this has been unsuccessful. Only by continuous pumping of groundwater into the wetland will it survive in a small area (Figure 35), and it is therefore likely to disappear altogether unless uncontrolled access to groundwater is curbed.

Figure 35 Azraq wetland, Jordan

Riparian- and swamp forests

Foerested freshwater wetlands are often special cases, as trees are more difficult to re-establish than herbaceous vegetation types, and often also often of a value as a fuel or for timber production. In the case of peat swamp forests, the degradation of these forests is often irreversible, as peat dries out after logging (whereby canals are excavated to extract logs), peat subsides and fires often occur. Re-establishing peat swamp forests on degraded peatland remains very challenging, costly and with a high likelihood of failure (Giesen & van der Meer, 2009). Riparian forests are easier to re-establish, although it remains important to remove or reduce competition with herbaceous species, and reduce herbivory (Sweeney *et al., 2002).*

Restoring wetland hydrology

Restoration and rehabilitation of wetland hydrology is a key part of habitat restoration, but dealt with separately here as it is of key concern to wetland managers. Iran is an arid country, and over the past years it has witnessed a prolonged and serious drought that has seriously affected many of the country's wetlands, including lakes Parishan and Uromiyeh. Excessive water use in the catchments has further exacerbated the problems caused by drought, such as decline in water levels (both LP and LU), increases in salinity (LU) and subsequent reduction in numbers of various species (e.g. flamingo and *Artemia at LU, fish at LP).*

Drought is a recurrent event in arid countries, and what we are witnessing in Iran *over the past few years may be part of a natural cycle. Iran is not alone in facing serious drought, and until early 2011, southeast Australia also witnessed its most serious drought in 200 years (Bond et al., 2008). However, climate change may also play a role, and only detailed analysis of long-term data can help determine this. It is known that wetlands are among the ecosystems most vulnerable to climate change (Ramsar fact sheet*6), so such possible changes should be closely monitored and carefully assessed.

Flow regimes on most regulated rivers (i.e. rivers with dams and other structures) can be restored by increasing environmental flows and allocations for downstream wetlands (such as lakes). The alteration of dam operations can also improve river health, for example, by modifying structures on dams (e.g. fish ladders, off-takes at several levels), restoring (connections with) floodplains and improving flow. Further, time-limited licensing for dams is an option (Kingsford, 2011). In Australia, buy back programmes are purchasing back water allocation rights from the private sector and re-allocating to the environment (Bond *et al., 2008; Crase et al., 2009). The Department of Land and Water Australia established a nation-wide "Environmental Water Allocation R&D Program*7" that included various programs on the country's main river system: the Murray-Darling.

Groundwater must also be taken into account, as this may be a major source of incoming waters into wetlands, and certainly also plays a significant role in both LP and LU in Iran. Managing the (often uncontrolled) use of groundwater must form part of the considerations and approaches taken in any hydrological restoration programme.

One of the main management approaches available is developing a greater efficiency of water use, as in many cases this is (very) low. Managers may promote a shift to crops with a lower water requirement, reduce losses along canals (e.g. seepage losses), use pipes instead of canals (reducing evaporation losses), and on-demand small-scale watering instead of large scale sprinklers. A key tool in promoting efficiency in water usage (used in many countries) is payment for water, as in many cases water is not paid for at all (simply provided), or provided at well below cost.

Some examples:

In Jordan, for example, farmers along the Jordan River grow 'thirsty' crops such as

6- http://www.ramsar.org/pdf/info/services_10_e.pdf
7- http://lwa.gov.au/files/products/environmental-water-allocation/pb071335/pb071335.pdf

banana and watermelon even though water is very scarce – this is because there is no system in place for payment for water at real value.

In Pakistan, the Marala-Ravi link canal (a major off-take system from the Indus River) was restored (re-lined) in the late 1990s when it became clear that 40% of all water was lost through seepage.

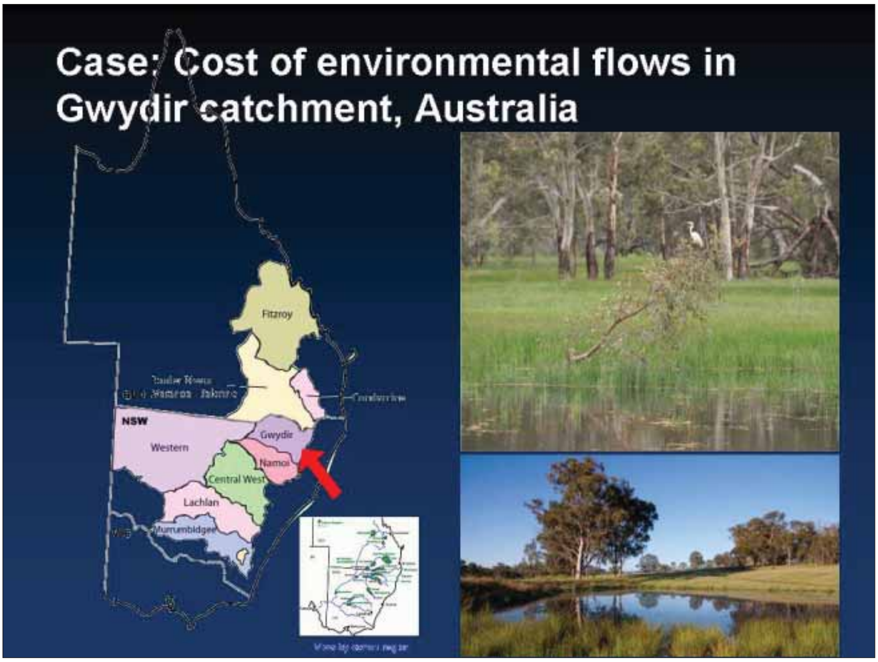
The EU Water Framework Directive calls for a system for realistic payment for water being put in place by all member states by 2012.

In spite of the best intentions, restoring flows is often very difficult if water use remains uncontrolled (see 5.1.5 and the case of the Azraq wetlands, Jordan). Provision of increased environmental flows and allocations for wetlands (e.g. via buy-back programmes) often lead to discussions about costs, and are often regarded as a burden to the economy as water could readily be used, for example for agriculture. In practice, however, the costs of environmental flows are rarely calculated and decisions are often made on the basis of intuition rather than detailed analysis. Such studies can be beneficial, as they can help support management decisions (see case on Gwydir catchment).

Case: Cost of environmental flows in Gwydir catchment, Australia

Environmental flow provision in the Gwydir catchment in New South Wales, Australia, under the Gwydir Water Sharing Plan, aims at improving wetland and aquatic ecosystems' health. However, farmers are concerned that implementation of the plan could lead to significant reductions in irrigation water, and managers worry about economic costs. A study was therefore carried out on the value ecosystem services from provision of environmental flow (Karanja et al., 2008; Figure 36). The economic cost related to provision of environmental flow (40 gigalitre), valued as the opportunity cost of foregone agricultural profit in Gwydir was A$15 million. The total economic value of four ecosystem services (waterbird-breeding events, habitat provision, improved wetlands grazing and biodiversity benefits (native fish species) totalled A$94 million, <u>more than six times the value of irrigation water.</u>

Figure 36 Gwydir Catchment, Australia



Wildlife species reintroduction

Re-introduction of wildlife species needs to meet a host of criteria if they are to be carried out carefully, for example, according to the criteria developed by IUCN8 and the various IUCN Specialist Groups. There are many potential problems associated with re-introducing wildlife, and many aspects need to be considered, including:

Is the species in question locally extinct, or are there remnant populations that could suffer further under a re-introduction program?

Does the donor stock have the same genotypic makeup as the original population? This is rarely the case as there are many regional differences between species (and even sub-species), but in re-introductions the aim should be for a closest similarity.

The risk of accidental introduction of disease, or genetic weaknesses.

Is the threat that affected the original population still persistent, or has this been removed? If still persistent, then reintroduction is likely to fail.

The recipient site should be favourable for the species in terms of foraging, breeding,

8- http://www.iucn.org/about/work/programmes/species/publications__technical_documents/publications/iucn_guidelines_and__policy__statements_/

and in terms of safety.

Removal of individuals from a donor stock should not affect the donor population.

Capture and handling of species for translocation should not result in mortality of (often endangered or vulnerable) species.

Captive breeding programs used for restocking depleted populations carry the risk of genetic erosion, altered animal behaviour (e.g. animals accustomed to human presence) and may carry diseases not prevalent in the wild.

Animals must be released in appropriate gender ratios, healthy, and of appropriate age.

Monitoring of released animals must be undertaken to assess the success rate of the program.

Case: reintroduction of fish in the Great Lakes of North America

The indigenous fish fauna of the Great Lakes in North America have suffered well-documented losses that varied among lakes. Originally, the fauna restricted to the lakes proper, i.e., the lakes themselves, was dominated by lake trout (Salvelinus namaycush), ciscoes (Coregonus spp.), and sculpins (Cottus and Myxocephalus). By the 1950s losses of these fishes were nearly complete in the lower lakes (Erie and Ontario) and severe in lakes Michigan and Huron. However, no species were lost from Lake Superior proper. Efforts to reintroduce extirpated lake-proper fishes have been confined to a single form of one species—the lean lake trout. Interest in reintroduction of other extirpated species, however, is emerging from management agencies and the public, and both cisco and deepwater trout are being considered (Eshenroder, 2002).

Case: New Zealand Frog Reintroductions

Hamilton's Frog was, until recently, considered to exist on two islands, Stephens Island and Maud Island and is considered endangered. However, the two populations have now been divided into separate species based on electrophoresis. Only the Stephens Island form is now considered to be Leiopelma hamiltoni, and the Maud Island form is L. pakeka. 300 Leiopelma pakeka were translocated from Maud Island, May 1997, to Motuara Island with the aim of establishing L. pakeka on another predator-free off shore island. Similarly, 60 frogs were translocated to Karori Wildlife Sanctuary on the mainland in 2006, 30 mainly female frogs in February, 30 mainly male frogs directly from Maud Island in October.

Lessons on restoration and reintroduction

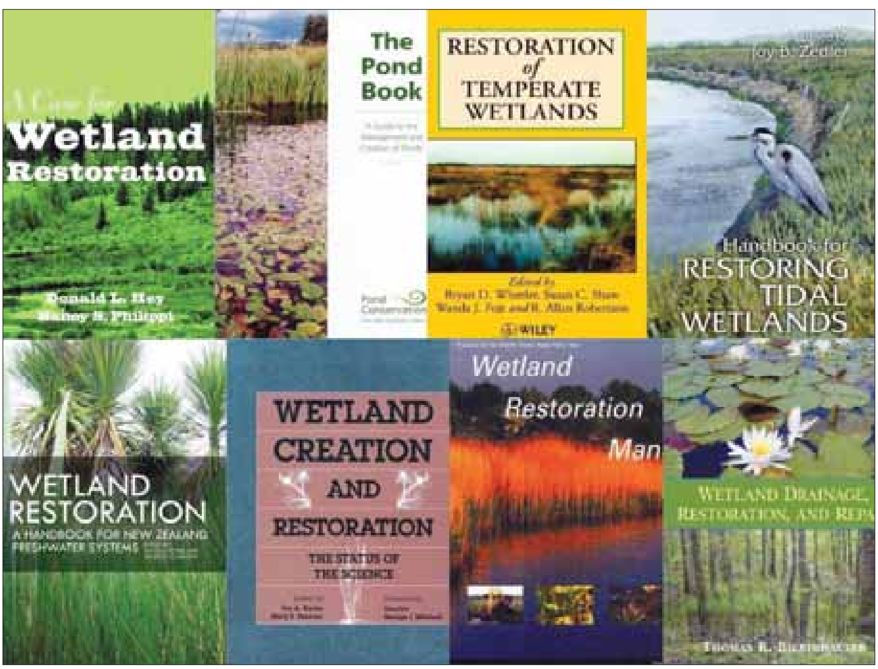
The key lesson to be learned regarding restoration of wetland habitats and wildlife reintroduction is that these are best avoided and should only be seen as last resort measures. It is much more cost effective to prevent degradation of the habitat or loss of a species, as restoration and reintroduction programs are often expensive and may fail.

In Iran, major issues facing the country's wetlands concern drought (largely a natural phenomenon) and excessive water use. Under such circumstances, restoration attempts need to include (at least temporary) re-allocation of water, in this case from agriculture to the wetlands.

Although re-allocation of water to wetlands may result in lowered outputs from irrigated agriculture, economic studies elsewhere show that such re-allocations may actually result in a nett economic benefit.

Many manuals exist on wetland restoration (Figure 37), often focusing on a particular wetland types, and/or a certain geographic region. Wetland managers should consult these before undertaking a restoration programme.

Figure 37 Wetland restoration manuals



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Conservation of Iranian Wetlands Project

Management Guidelines For Implementation

Biodiversity Management Of Wetlands

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